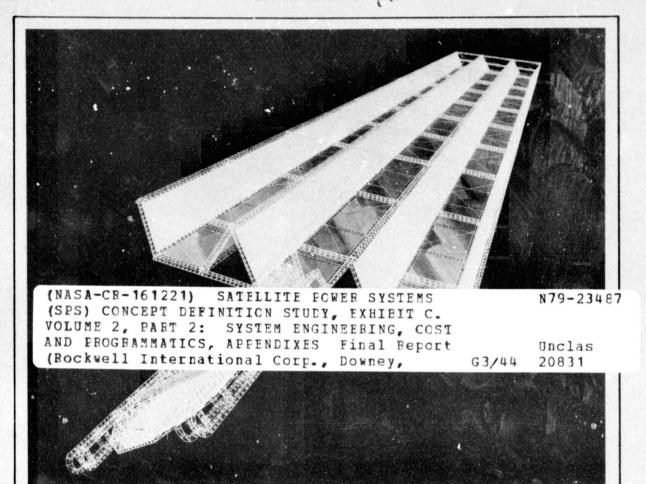
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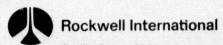


Satellite Power Systems (SPS) Concept Definition Study

FINAL REPORT (EXHIBIT C)
VOLUME II

SYSTEM ENGINEERING

PART 2
(COST AND PROGRAMMATICS – APPENDIXES)



Satellite Systems Division Space Systems Group 12214 Lakewood Boulevard Downey, CA 90241

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> **CONTRACT NAS8-32475** DPD 558 MA-04

> > March 1979

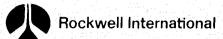
Approved

SPS Study Team Manager, NASA/MSFC

Prepared for:

National Aeronautics and Space Administration George C. Marshall Space Flight Center

> Marshall Space Flight Center Alabama 35812



Satellite Systems Division Space Systems Group

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FOREWORD

Volume II, System Engineering, is presented in two parts. Part 1 encompasses SPS system engineering aspects. Part 2 consists of a volume on SPS cost and programmatics; an appendix is included in Part 2 to cover the SPS WBS and cost estimates. Volume II of the SPS Concept Definition Study final report is submitted by Rockwell International through the Satellite Systems Division. All work was completed in response to NASA/MSFC Contract NAS8-32475, Exhibit C, dated March 28, 1978.

The SPS final report will provide the NASA with additional information on the selection of a viable SPS concept, and will furnish a basis for subsequent technology acvancement and verification activities. Other volumes of the final report are listed as follows:

Volume	Title	ini≢ kan at Bija	
T .	Executive Summary		
III	Experimentation/Verification	Element	Definition
IV	Transportation Analyses		
V	Special-Emphasis Studies		
VΙ	In-Depth Element Investigation	ns	
VII	Systems/Subsystems Requiremen	ts Data	Book

The SPS Program Manager, G. M. Hanley, may be contacted on any of the technical or management aspects of this report. He can be reached at 213/594-3911, Seal Beach, California.

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ACKNOWLEDGEMENTS

Since the publication of earlier Rockwell SPS cost, economic, and programmatic documentation—dating back to 1976—a continuing effort has been maintained to incorporate the latest program developments, expand the Rockwell SPS cost model; conduct comparative cost/economic analyses; prepare integrated schedules or networks; and define SPS program plans and resource requirements. The results of this work represent a professional contribution on the part of many individuals, where most of them have been with the SPS contract activity and supplementing company-sponsored efforts since the start of our effort. It is this contribution that requires acknowledgement.

The overall study activity was also supported by other business/industrial organizations and technical members of the SPS program team and their management, making it possible to reach the desired conclusions with the minimum of effort.

The Rockwell SPS program development team that contributed to the search, analyses, and results of this study are:

• Dr. L. R. Blue

Cost/Risk Programming

· W. Cooper

Cost Analysis

• D. E. Lundin

SPS Schedules/Networks

• A. D. Kazanowski

Resource Analysis

The overall SPS program development activity on SPS costs, schedules, program planning, resource analysis, and computer programming was completed under the direction of F. W. Von Flue.

The help and support of personnel from NASA/MSFC and the SPS Program Planning Office is also acknowledged.

- · Engineering Cost Group
 - W. S. Rutledge
 - J. W. Hamaker
 - D. T. Taylor
- · Program Plans and Requirements Group
 - W. A. Ferguson
 - H. K. Turner

APPENDIX A SATELLITE POWER SYSTEM WORK BREAKDOWN STRUCTURE DICTIONARY

SOLAR PHOTOVOLTAIC GaAIAS CONCENTRATION RATIO (CR) - 2 THREE-TROUGH COPLANAR END-MOUNTED ANTENNA

APPENDIX A SATELLITE POWER SYSTEM WORK BREAKDOWN STRUCTURE DICTIONARY

INTRODUCTION

Generally a work breakdown structure (WBS) is thought to be a productoriented family tree composed of all the hardware, software, services, and other tasks necessary to define the program. It offers visual display, relates project elements, and defines the work to be accomplished. The WBS is then a tool for facilitating communications and understanding a complex program by dividing this program into less complex, more manageable subdivisions or elements. It is most desirable that the WBS provide a uniform basis for management and control, cost estimating, budgeting and reporting, scheduling activities, organizational structuring, specification tree generation, weight allocation and control, procurement and contracting activities, and serve as a tool for program evaluation. Therefore, the WBS developed and defined herein is primarily tailored to the unique cost, economic, and programmatic requirements of the Satellite Power System (SPS). It is designed to allow a standard and logical format for estimating SPS project cost, while at the same time permitting cost and economic comparisons of SPS to alternate and competitive candidates for producing power.

WBS MATRIX

The total WBS matrix shown in Figure A-1 is a three-dimensional structure that shows the interrelationship of (1) the hardware and activities dimension, (2) the accounts and phases dimension, and (3) the elements of cost dimension. This latter dimension is not further developed at this time, but is provided to show the overall expansion capability built into the WBS matrix. This dimension will become more important in later years when the SPS program approaches a Phase C/D start and is defined to the extent that the elements of cost can be planned and estimated with realism.

There is, of course, the fourth dimension of time which cannot be graphically shown but must be considered also. Each entry on the other three dimensions varies with time, and it is necessary to know these cost values by year for budget planning and approval, and to establish cost streams for discounting purposes.

While a multiple-dimensional approach may at first appear unduly complex, it actually provides benefits that far outweigh any such concern. This structural interrelationship provides the capability to view and analyze the SPS from a number of different financial and management aspects. Costs may be summed by hardware groupings, phases, functions, etc. The WBS may be used in a number of three-dimensional, two-dimensional, or single-listing format applications.

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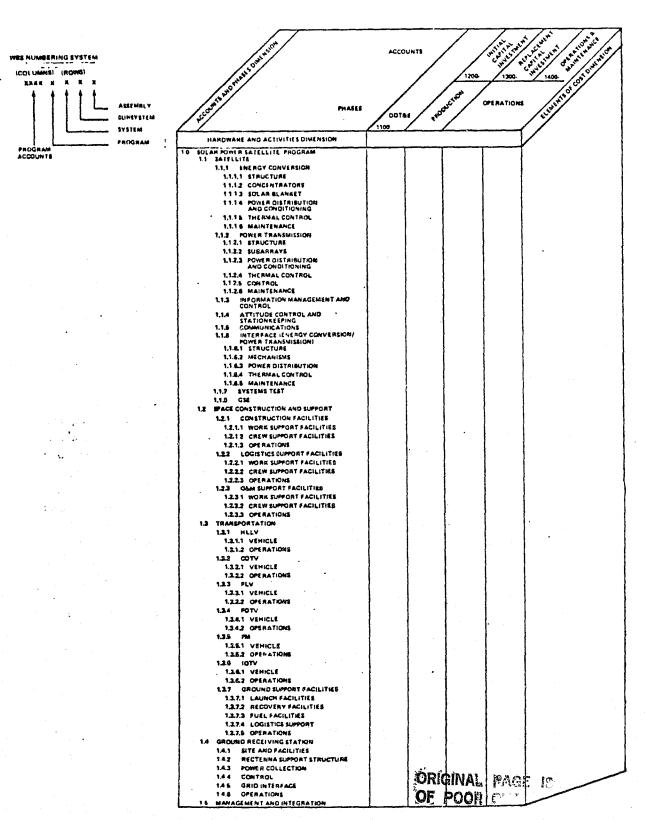


Figure A-1. Satellite Power System Work Breakdown Structure

ACCOUNTS AND PHASES DIMENSION

The accounts and phases dimension differs somewhat from the typical breakout for government aerospace programs in that it has been developed to also
accommodate the financial involvement of the private sector, hence, the inclusion of the breakout of financial divisions or "accounts." Distinctions have
been made between capital expenditures, which are recoverable by annual depreciation charges and are not deductible as expenses, and operation and maintenance charges against income, which are deductible as expenses in the year
incurred.

To accomplish this objective, four financial accounts have been established. Design, development, test, and evaluation (DDT&E) includes the one-time costs associated with the development of components, subsystems, and systems required for the SPS project. Initial capital investment includes the costs associated with initial procurement and emplacement of the SPS plant and equipment. Replacement capital investment includes the costs associated with capital asset replacements over the operating life of the SPS (e.g., subsystem spare parts, overhauls, etc.). Operations and maintenance (O&M) includes the costs of expendables (e.g., propellants for the propulsion subsystem thrusters), minor maintenance, repair crews, etc. The interrelationship of the financial accounts to the normal aerospace program phases of DDT&E, investment, and operations are also shown in this dimension of the WBS matrix to permit traceability to these more commonly recognized therms.

HARDWARE AND ACTIVITIES WBS DIMENSION

The hardware and activities WBS dimension contains hardware elements of the satellite system and ground system subdivided into subsystems and assemblies. Inherent within this dimension is the capability for further subdivision to lower levels of detail limited only by the realism of the requirements.

Required support hardware, possibly developed under the sponsorship of other programs, is also displayed here for completeness and includes such items as space construction and support equipment and transportation vehicles. Some or all of these support elements may be developed for multiple project applications. A determination will be made later as to how much, if any, of the development costs of these support elements should be charged against the SPS program.

Each of the elements of support hardware is broken out only at a summary level within the SPS WBS. However, they each have their own detailed WBS which could be displayed in depth under the SPS WBS if required.

Finally, the hardware and activities WBS dimension also includes the necessary activities of management, integration, operations, etc., required to accomplish the overall SPS missions.

DICTIONARY ORGANIZATION

The SPS dictionary is divided into:

- (1) A graphic display of the three-dimensional WBS matrix (Figure A-1)
- (2) The definitions of terms of the accounts and phases dimension (pages A-5 and A-6)
- (3) The definitions of terms of the WBS hardware and activities dimension (pages A-7 through A-16)

A systematic numerical coding system coordinates the rows of the hardware and activities dimension to the columns of the accounts and phases dimension such that all matrix locations are identifiable by WBS number.

Since each matrix position corresponds to one particular row of the hard-ware and activities dimension and also to one particular column of the accounts and phases dimension, a complete definition of any matrix position is constructed by combining the definitions from the two applicable dimensions. That is, to avoid repetition, definitions are provided only once for each hardware and activities dimension row and only once for each accounts and phases dimension column, and a complete definition for any matrix position is a combination of these two definitions.

DEFINITIONS OF ACCOUNTS AND PHASES

1100—DESIGN, DEVELOPMENT, TEST, AND EVALUATION (DDT&E)

The DDT&E account/phase consists of the one-time costs associated with designing, developing, testing, and evaluating the components, subsystems, and systems required for the SPS project. It includes the development engineering, testing, and support necessary to translate a performance specification into a design. It encompasses the preparation of detailed drawings for system hardware fabrication, system integration, and (depending on the system, subsystem, or component) structural, environmental, and other required tests. It includes all ground tests, sortie tests, subscale and full-scale SPS tests, and all hardware fabrication required for such tests. Also included are the analysis of data and whatever redesign and retest activities are necessary to meet specifications. It also includes ground support equipment, special test equipment, and other program-peculiar costs not associated with repetitive production. All SPS related support systems such as transportation, space construction base, and assembly/support equipment necessary to accomplish the DDT&E phase are included at present for completeness. It may later be determined that some of these support systems will exist with or without SPS; therefore, they may not be chargeable to the SPS project.

1200—INITIAL CAPITAL INVESTMENT

The initial capital investment account is a summation of those plant and equipment expenditures made for the initial procurement and installation of each full-scale SPS. That is, this account collects the production, assembly, installation, transportation, test, etc., costs of each individual satellite and ground station that is associated with, and necessary to, bringing the power plant online (in government aerospace terminology, this corresponds to costs in the investment phase). Examples of costs collected in this account are the procurement cost and launch cost of the satellite system itself, the procurement cost of the ground system (including installation), and all other necessary costs to achieve this end such as those attributable to space stations, launch vehicle fleets, etc. Also included is pro rata share of such functional costs as program management, SE&I, etc., related to the foregoing systems. Only costs incurred after the end of the DDT&E phase and prior to the initial operational capability (IOC) of each SPS are collected in this account.

1300-REPLACEMENT CAPITAL INVESTMENT

The replacement capital investment account is a summation of those plant and equipment expenditures made for capital asset replacement and major over-hauls that are expected to last more than one year and result in an improvement to the operating system. Examples of costs collected in this account are the costs of spares, their installation and associated launch costs or ground transportation costs, permanent improvements in the system such as rotary joint replacement, installation of improved design satellite control equipment, etc.,

as well as pro rata shares of functional costs. These expenditures begin at the IOC and continue over the life of each SPS.

1400—OPERATIONS AND MAINTENANCE (O&M)

The 0&M account is a summation of those expenditures incurred in the day-to-day operations beginning with the IOC and continuing over the life of each SPS. Examples of costs collected in this account are wages of operations and maintenance personnel, minor repairs and adjustments to systems to maintain an ordinarily efficient operating condition, expendables and consumables, launch costs for transfer of on-orbit personnel and resupply of expendables and consumables, etc.

DEFINITIONS OF HARDWARE AND ACTIVITIES

1.0 SATELLITE POWER SYSTEM PROGRAM

The program includes all the elements of hardware, software, and activities required for the design, development, production, assembly, transportation, operations, and maintenance of the SPS program systems. Included are the satellite and ground receiving station systems, as well as the necessary support systems such as space construction and support and transportation.

1.1 SATELLITE

This element includes the hardware and software located in geosynchronous orbit (GEO) for the collection of solar energy, conversion to electrical energy, and transmission of electrical energy in microwave form to earth.

1.1.1 ENERGY CONVERSION

This element includes the components required to collect solar energy, convert the solar energy to electrical energy, condition the electrical energy, and transport it to the interface wubsystem (WBS No. 1.1.6).

1.1.1.1 STRUCTURE

This element includes all necessary members to support the concentrators, solar blankets, and other energy conversion subsystem hardware. It includes structural beams, beam couplers, cables, tensioning devices, and secondary structures which are required as an interface between the primary structure and the mounting attach points of components, assemblies, and subsystems.

1.1.1.2 CONCENTRATORS

This element concentrates the solar energy onto the solar blanket to increase the energy density on the conversion device. It includes the reflective material and any integral attach points required for mounting. Excluded are tools and support equipment required for deployment and tensioning.

1.1.1.3 SOLAR BLANKET

This element converts solar energy to electrical energy and provides power to the power distribution and conditioning buses. It includes the photovoltaic conversion cells, coverplates, substrate, electrical interconnects, and any integral attach points required for mounting. Excluded are tools and support equipment required for deployment and tensioning.

1.1.1.4 POWER DISTRIBUTION AND CONDITIONING

This element includes the power conductors, switch gear, and conditioning equipment and slip rings required to transfer power from the solar blanket to the interface subsystem power distribution elements. Also included are electrical cables and harnesses required to distribute power to equipment located on

the energy conversion structure, plus batteries or storage medium for information system and attitude control. Excluded are data buses which are included in the information management and control subsystem (WBS No. 1.1.3).

1.1.1.5 THERMAL CONTROL

This element includes any component used to modify the temperature of the energy conversion subsystem components. It includes coldplates, heat transfer, and radiator devices, as well as insulation, thermal control coatings, and finishes. Excluded are paints or finishes applied to components during their manufacturing sequence.

1.1.1.6 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and in situ repair equipment.

1.1.2 POWER TRANSMISSION

This element receives do electrical power from the interface subsystem, conditions the power, converts it to microwave energy, and radiates the energy to the ground receiving station. Included are power distributions from the interface subsystem, do-to-RE conversion devices, control and monitoring equipment, and antenna radiating elements.

1.1.2.1 STRUCTURE

This element includes all members necessary to support the transmitter subarrays and other power transmission subsystem hardware. It includes structural beams, beam couplers, cables, tensioning devices, and secondary structures.

1.1.2.2 TRANSMITTER SUBARRAYS

This element includes all the hardware required for generation, distribution, phase control, and radiation of microwave energy. This includes the subarray structure, waveguides, power amplifiers, phase control electronics, and power harnesses. Also included are thermal control devices and finishes that are manufactured as an integral part of the subarray.

1.1.2.3 POWER DISTRIBUTION AND CONDITIONING

This element includes the power conductors, switch gear, and conditioning equipment required to transfer power from the interface subsystem to the subarray wiring harnesses and to any other power-consuming/storage equipment located on the power transmission structure, such as batteries.

1.1.2.4 THERMAL CONTROL

This element includes any component used to modify the temperature of power transmission subsystem components. It includes coldplates, heat transfer and radiator devices, as well as insulation, thermal control coatings, and finishes. Excluded are paints and finishes applied to components during their

manufacturing sequence and thermal control devices that are an integral part of another component.

1.1.2.5 CONTROL

This element provides the reference phase for all subarray phase conjugating circuits. This includes the reference oscillator signal distribution and frequency conversion equipment plus components that commonly serve all subarrays.

1.1.2.6 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and in situ repair equipment.

1.1.3 INFORMATION MANAGEMENT AND CONTROL

This element includes those components that process information on board the satellite. This includes sensing, signal conditioning, formatting, computations, formulation and signal routing.

1.1.4 ATTITUDE CONTROL AND STATIONKEEPING

This element includes the components required to orient and maintain the satellite's position and attitude in GEO. Included are sensors, reaction wheels, chemical and electric propulsion hardware, and propellants.

1.1.5 COMMUNICATIONS

This element includes the hardware to transmit and receive intelligence among the various SPS elements. This includes communication of both data and voice between the SPS and the control center, as well as among the various cargo and personnel vehicles. Excluded is intravehicular and intrasatellite communications.

1.1.6 INTERFACE (ENERGY CONVERSION/POWER TRANSMISSION)

This element provides the movable interface between the energy conversion subsystem and the power transmission subsystem. A 360° rotary joint and an antenna elevation mechanism are required to maintain proper alignment of the transmitter with the ground receiving station. Included are structure, mechanisms, power distribution, thermal control, and maintenance hardware.

1.1.6.1 STRUCTURE

This element includes all members necessary to provide a mechanical interface between the primary structures of the energy conversion subsystem and the power transmission subsystem. It includes beams, beam couplers, cables, tensioning devices, and secondary structures. Excluded are elements of the drive assembly which are included in mechanisms (WBS No. 1.1.6.2).

1.1.6.2 MECHANISMS

This element includes the components required to rotate and elevate the power transmission subsystem. Included are the drive ring, bearings, gear drives and drive motors.

1.1.6.3 POWER DISTRIBUTION

This element provides for the transfer of electrical power through the interface. It includes slip rings, brush assemblies, feeders, and insulation.

1.1.6.4 THERMAL CONTROL

This element includes any component used to modify the temperature of interface subsystem components. It includes coldplates, heat transfer and radiator devices, as well as insulation, thermal control coatings, and finishes. Excluded are paints or finishes applied to components during their manufacturing sequence.

1.1.6.5 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and in situ repair equipment.

1.1.7 SYSTEMS TEST

This element includes the hardware, woftware, and activities required for ground-based systems tests including qualification tests and other development tests involving two or more subsystems or assemblies. It includes the production, assembly, integration, and checkout of satellite system hardware into a full or partial system test article. It also includes the design, development, and manufacture of special test equipment, test fixtures, and test facilities that are not included in other elements such as ground support faciliteis. Also included are the planning, documentation, and actual test operations.

1.1.8 GROUND SUPPORT EQUIPMENT (GSE)

This element includes all ground-based hardware required in support of handling, servicing, test, and checkout of the satellite subsystems. It also includes special hardware required for simulations and training.

1.1.9 PRECURSOR TEST ARTICLE

The precursor pilot plan test article and operations are included in this element. It represents a test vehicle that consists of an energy conversion, interface, and power transmission segment.

1.2 SPACE CONSTRUCTION AND SUPPORT

This element includes all hardware and activities required to assemble, check out, operate, and maintain the satellite system. Included are space stations, construction facilities, support facilities and equipment, and manpower operations.

1.2.1 CONSTRUCTION FACILITIES

This element includes the facilities, equipment, and operations required to assemble and check out the satellite system. Included are crew life support facilities, the central control facility, fabrication and assembly facilities, cargo depots, and operations.

1.2.1.1 WORK SUPPORT FACILITIES

This element includes the facilities and equipment required for satellite assembly and checkout. Included are beam fabricators, manipulators, assembly jigs, installation and deployment equipment, and cargo storage depots. Excluded are the facilities related to crew support.

1.2.1.2 CREW SUPPORT FACILITIES

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, center control facilities, recreation facilities, and health facilities of the satellite construction base.

1.2.1.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the construction facility. It includes both the direct and support personnel and the expendable maintenance supplies required for satellite assembly and checkout.

1.2.2 LOGISTICS SUPPORT FACILITIES

This element includes the hardware, software, and operations required in low earth orbit (LEO) to support the construction and operations and maintenance of the satellite system. Included are crew life support facilities, cargo and propellant depots, and vehicle servicing facilities necessary for the receiving, storage, and transfer of cargo and personnel destined for a construction base or operational satellite located in GEO.

1.2.2.1 WORK SUPPORT FACILITIES

This element includes the facilities and equipment required to provide logistics support in LEO. Included are heavy-lift launch vehicle (HLLV) and orbital transfer vehicle (OTV) docking stations, payload handling equipment, and cargo and propellant storage depots. Excluded are facilities related to crew support.

1.2.2.2 CREW SUPPORT FACILITIES

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, recreation facilities, and health facilities of the LEO Base.

1.2.2.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the logistics support facility. It includes both the direct and support personnel and the expendable maintenance supplies required for logistics support.

1.2.3 O&M SUPPORT FACILITIES

This element includes the facilities, equipment, and operations required in GEO to support the operations and maintenance of the satellite system. Included are the on-orbit monitor and control facility and the life support facilities and equipment required to provide comfortable, safe living quarters for the resident crew members.

1.2.3.1 WORK SUPPORT FACILITIES

This element includes the facilities and equipment required for operation and maintenance of the satellite system. Included are satellite monitor and control stations and any centralized repair facilities not included under maintenance (WBS Numbers 1.1.1.6, 1.1.2.6, and 1.1.6.5).

1.2.3.2 CREW SUPPORT FACILITIES

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, recreation facilities, and health facilities.

1.2.3.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the O&M support facility. It includes both the direct and support personnel and the expendable maintenance supplies required in GEO for satellite operations and maintenance.

1.3 TRANSPORTATION

This element includes all space transportation required to support the satellite system assembly and operation; and the ground support facilities to provide a launch, recovery, propellant, logistics, and operational capability. Included are the launch to LEO and the orbit-to-orbit transfer of all hardware, materials, and personnel required during the construction and lifetime operation of the satellite system.

1.3.1 HEAVY-LIFT LAUNCH VEHICLE (HLLV)

This element includes the HLLV vehicles and operations required to support the satellite system assembly and operation. Included is the launch to LEO of all space construction and support equipment, satellite system hardware, OTV's, propellants, and other consumables required throughout the satellite lifetime.

1.3.1.1 HLLV VEHICLE

This element includes the vehicle fleet procurement required to support the SPS project.

1.3.1.2 HLLV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS project.

1.3.2 CARGO ORBITAL TRANSFER VEHICLE (COTV)

This element includes the COTV vehicles and operations required to support the satellite system assembly and operation. Included is the LEO-to-GEO transfer of space construction and support equipment, satellite system hardware, spares, and propellants required throughout the satellite lifetime.

1.3.2.1 COTV VEHICLES

This element includes the vehicle fleet procurement required to support the SPS project.

1.3.2.2 COTV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS project.

1.3.3 PERSONNEL LAUNCH VEHICLE (PLV)

This element includes the PLV and cargo vehicles of the growth Shuttle and operations required to support the satellite system assembly and operation. Included is the launch to LEO and return of all personnel and priority cargo required throughout the satellite construction period and operational lifetime.

1.3.3.1 PLV VEHICLES

This element includes the vehicle fleet procurement required to support the SPS project. Included are the vehicles for personnel transfer from earth to LEO and for cargo transfer as needed to support elements of the precursor phase of program development.

1.3.3.2 PLV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS project.

1.3.4 PERSONNEL ORBITAL TRANSFER VEHICLE (POTV)

This element includes the POTV vehicles and operations required to support the satellite system assembly and operation. Included is the LEO to GEO and return transfer of all personnel and priority cargo required throughout the satellite construction and operational periods.

1.3.4.1 POTV VEHICLES

This element includes the vehicle fleet procurement required to support the SPS project.

1.3.4.2 POTV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS project.

1.3.5 PERSONNEL MODULE (PM)

This element includes the PM units and operations required to support the satellite system assembly and operation. Included is the LEO to GEO and return transfer of all personnel and critical hardware items required throughout the satellite construction and operational periods. The PM provides a crew habitat during the orbit-to-orbit transfers of personnel.

1.3.5.1 PM VEHICLES

This element includes the PM unit procurement required to support the SPS project.

1.3.5.2 PM OPERATIONS

This element includes the necessary operations (user charge per flight including payload integration) required to support the SPS project.

1.3.6 INTRA-ORBITAL TRANSFER VEHICLE (IOTV)

This element includes the IOTV vehicles and operations required to support the satellite system assembly and operation. Included is the intra-orbit transfer of cargo between the HLLV, COTV, construction facility, logistics support facility, and operational satellites.

1.3.6.1 IOTV VEHICLES

This element includes the necessary vehicle fleet procurement required to support the SPS project.

1.3.6.2 IOTV OPERATIONS

This element includes the necessary vehicle operations (recurring refurbishment and propellant costs) required to support the SPS project.

1.3.7 GROUND SUPPORT FACILITIES

This element includes all land, buildings, roads, shops, etc., required to support the cargo handling, launching, recovering, refurbishment, and operations of the space transportation system.

1.3.7.1 LAUNCH FACILITIES

This element includes the design and construction of the actual launch facility and its associated equipment. Included are land, buildings, and equipment required to support the various crews. It also includes the required control centers and administrative facilities.

1.3.7.2 RECOVERY FACILITIES

This element covers the design, construction, and equipping of the actual recovery facilities.

1.3.7.3 FUEL FACILITIES

This element includes fuel production facilities, storage and handling facilities, transportation, and delivery and safety facilities for both the fuel and the oxidizer. Also included are the facilities for fuels used in the various orbital transfer facilities.

1.3.7.4 LOGISTICS SUPPORT

This element includes the land, buildings, and handling equipment for the receiving, inspection, and storage and packaging of all payloads to be launched except for fuels and oxidizers.

1.3.7.5 OPERATIONS

This element includes the planning, development, and conduct of operations at the ground support facilities. It includes both the direct and support personnel and the expendable maintenance supplies required for the ground support facilities operation and maintenance.

1.4 GROUND RECEIVING STATION

This element includes the land, facilities, and equipment that comprise the ground subsystems utilized to receive the radiated microwave power beam and to provide the power at the required voltage and type of current for entry into the national power grid. Also included are the equipment and facilities necessary to provide operational control over the satellite.

1.4.1 SITE AND FACILITIES

This element encompasses the site and facilities for the ground receiving station system which includes the rectenna, grid interface, and satellite control subsystems. Included are the land, site preparation, roads, fences, utilities, lightning protection, buildings, and maintenance equipment required to house and support the other ground station subsystems.

1.4.2 RECTENNA SUPPORT STRUCTURE

This element includes the hardware, materials (steel and concrete), and assembly operations necessary to erect the physical support for the rectenna array elements of WBS No. 1.4.3.

1.4.3 POWER COLLECTION

This element includes the antenna array elements associated with the actual reception and rectification of the microwave radiation. These elements are in series and parallel as required to deliver the required output voltage and



current. Also included are those components that accept the dc power from the array elements and route, control, convert, and switch this power for delivery to power conversion stations of the grid interface.

1.4.4 CONTROL

This element includes the hardware that will be used to monitor and control the satellite from the ground. Included are telemetry, tracking, communications, monitoring of microwave beam characteristics, computing phase corrections, and providing frequency standard signals for the satellite. Functional requirements provide for signal conditioning, formatting, software, computations, and signal routing.

1.4.5 GRID INTERFACE

This element includes the power conversion equipment that receives the electrical power from the power collection subsystem and conditions/converts it to a high voltage dc or ac power acceptable for input into the national power grid. Also included are those components necessary to route, control, and switch this power into the national power grid.

1.4.6 OPERATIONS

This element includes the planning, development, and conduct of operations at the ground receiving station. It includes both the direct and support personnel and the expendable maintenance supplies required for the ground station operation and maintenance.

1.5 MANAGEMENT AND INTEGRATION

This element includes all efforts and material required for management and integration functions at the systems level and program level. It encompasses the following functions:

- a) Program Administration
- b) Program Planning and Control
- c) Contracts Administration
- d) Engineering Management
- e) Manufacturing Management
- (f) Support Management
- (g) Quality Assurance Management
- (h) Configuration Management
- (i) Data Management
- (j) Systems Engineering and Integration

This element sums all of the direct effort required to provide management control, including planning, organizing, directing, and coordinating the project to ensure that overall project objectives are accomplished. These efforts overlay the functional work areas (e.g., engineering, manufacturing, etc.) and assure that they are properly integrated. This element also includes the efforts required in the coordination, gathering, and dissemination of management information. Also included are the engineering efforts related to the establishment and maintenance of a technical baseline for a system by generation of system configuration parameters, criteria, and requirements. It includes requirements analysis and integration, system definition, system test definition, interfaces, safety, reliability and maintainability. It also includes those efforts required to monitor the system development and operations to ensure that the design conforms to the baseline specifications.

APPENDIX B SATELLITE POWER SYSTEM COST ESTIMATING RELATIONSHIPS (CERs)

SOLAR PHOTOVOLTAIC GAALAS
CONCENTRATION RATIO (CR) - 2
THREE-TROUGH COPLANAR
END-MOUNTED ANTENNA
CONFIGURATION

APPENDIX B SATELLITE POWER SYSTEM COST ESTIMATING RELATIONSHIPS (CERs)

B.O INTRODUCTION

This appendix contains the cost analyses and a description of cost elements that comprise the SPS program. Each item is presented in accordance with the work breakdown structure of Appendix A and is responsive to the Rockwell reference configuration defined under Exhibit C of NAS8-32475 -- a 3-trough planar array with an end mounted tension web antenna (Figure B-1).

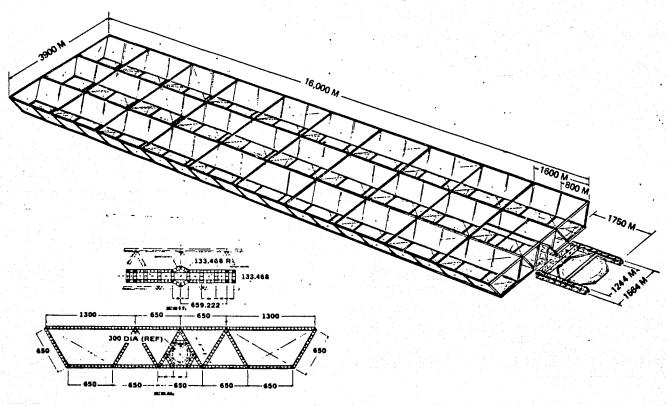


Figure B-1. SPS Reference Configuration

Subsequent sections of this appendix describe the definitions and ground rules used during the cost analysis; the methodology followed in developing estimates and the computer program; plus a detailed discussion of each subsystem, assembly, or component used in the analysis. These descriptions include design input parameters, cost estimates, scaling exponents/factors, and supporting computer program cost model equations for each of the WBS items.

B.1 COSTING GROUND RULES AND GUIDELINES

The following major ground rules and assumptions were used in the performance of this study:

- 1. The SPS WBS of Appendix A was used as the structure of program hardware, activities and accounts.
- 2. Key dates of program planning:

1980 - 1 1981 - 1				ry Research Activities	
1990		ision Point hase C/D)	for SPS	Commercial:	ization
2000	IOC	of First S	PS		

- 3. Costs are reported at WBS level in terms of:
 - (a) Development cost and TFU (theoretical first unit).
 - (b) Initial capital investment average cost per satellite (Satellites TFU and No. 2 through No. 60).
 - (c) Replacement capital investment (RCI) cost and operations and maintenance (O&M) cost per satellite per year.
- 4. Cost estimates are projected in 1977 dollars and maximum use was made of past SPS studies and other associated data as appropriate.
- 5. SPS build rate will be two nominal 5 GW SPS systems per year for 30 years to provide a total capacity of 300 GWs by 2030.
- 6. Overall SPS lifetime will be 30 years with minimum maintenance and no salvage value or disposition costs.
- 7. Complete construction and assembly will occur at GEO synchronous orbit.
- 8. Calculations based on 0% launch losses.
- 9. Program management and SE&I (management and integration) are costed at 5% of all other level 2 costs.
- 10. 25% mass contingency is costed as a 15% cost contingency on items 1.1, 1.2, and 1.3 of the SPS WBS.

B.2 COSTING METHODOLOGY

The approach followed in developing cost estimates for the SPS Program was based on the maximum use of contract and company sponsored work. The basic Rockwell - NASA/MSFC computer cost model was expanded considerably to incorporate the requirements of a revised WBS structure (Appendix A). The data base

of existing and proved CERs was expanded by grass roots analysis and specific engineering estimates on the flight vehicles and ground receiving station to provide cost projections based on industrial/consultant experience and on similar contract effort such as those of the Rockwell Space Shuttle and Space Station programs. Costing of some WBS elements utilized previously developed data with slight modification to incorporate reference systems specifications.

There are a series of equations that were used to deal with the four basic types of cost accounts and phases of the program -- DDT&E, initial capital investment, replacement capital investment, and operations and maintenance.

The DDT&E equation (CD) estimates the cost of the design, development, and test/evaluation of WBS line items for the satellite, space construction and support, transportation, and ground receiving station, plus management and integration support. Management and integration are costed as a separate line item at 5% of all other level two costs of the WBS. Because of the gross nature of the level of information/definition on systems test and GSE (ground support equipment), the cost of system test hardware, and system test operations, has been assumed to be one-half of the satellite system first-unit costs. A 10% factor of satellite DDT&E is used for GSE.

The appropriate inputs for the DDT&E CERs are the applicable total system mass, area, or power. A development factor is provided in the equation (DF) to adjust the cost to reflect only that portion of the total system mass, area or power considered necessary for development of the complete system where it is not required to develop the total mass, area or power. The CD cost equation also allows for the application of a complexity factor (CF) to adjust the cost results when it is determined that the item being estimated is either more or less complex than the CER base data.

The initial capital investment (ICI) cost equations estimate the initial capital investment cost of hardware items as a function of their mass, area or power. The ICI cost equation is expressed in four different forms -- CLRM, CTFU, CTB, and CIPS. The CLRM (cost of lowest repeating module) equation requires that the input correspond to the mass, area or power of the lowest repeating module (M). This is necessary because of the physical scale of the SPS and the production quantities required for many of the hardware elements. It is not reasonable to estimate the SPS initial capital investment cost as a historical function of the entire SPS mass, area or power. Instead, it is desirable to cost the number of repeating modules required per satellite to establish the satellite theoretical first-unit cost (TFU), and to input the satellite TFU cost into a progress (learning) function for the quantity of satellites required to calculate the average unit cost (CTB - cost to build). This calculation involves two steps in the cost equations. The first step (CLRM) is simply the portion of the equation which estimates the theoretical first repeating module cost as discussed above. The second step (CTFU) has the progress function incorporated into the equation for the quantity of repeat modules required for the first satellite. It automatically takes into account the progress over production quantities required when calculating the cost to build an average unit over the total option quantity. This CTB calculation is then the basis of CIPS, where the number of units to construct a satellite option are divided by the option quantity and then multiplied by the

CTB. In some ICI cost equations, such as those of SPS transportation, the space vehicle has a service life that is greater than that needed to construct a single satellite. The CIPS equation provides the cost model with a needed program flexibility.

At the current level of SPS definition, it was difficult to decide just what is a repeating module. It is often impossible to know with any certainty just what portion of the total mass is appropriate to run through the equation as a module. It is just as difficult to identify how many distinct types or designs of modules will be required for any subsystem or assembly. In such cases, the study simply assumed a module mass (or area or power) based on engineering best judgment.

Replacement capital investment (CRCI) CERs simply provide for the multiplication of the annual spares fraction (R) of each system by that system's cost to build in order to arrive at an RCI cost per satellite per year.

Operations and maintenance costs (CO&M) are estimated in terms of O&M cost per satellite per year. O&M costs include those expenditures incurred in day-to-day operations beginning with SPS initial operating capability (IOC) and continuing over the life of each satellite. They consist of wages of operations and maintenance personnel, minor repairs and adjustments to systems to maintain an ordinarily efficient operating condition, expendables and consumables, launch costs for delivery and transfer of on-orbit personnel and cargo resupply of expendables and consumables, etc.

The cost methodology seeks to account for five separate effects which influence SPS cost. These are scaling, specification requirements, complexity, the degree of automation, and production progress. Scaling refers to the relationship in cost between items varying in size, but similar in type. Economies of scale usually assure that such a relationship will not be strictly linear, but rather as size increases, cost per unit of size will decrease. The slope of this relationship is reflected by the equation exponent which results from the regression analysis of the data used to develop the cost estimating relationship.

Specification requirements have been accounted for by normalizing the CER data base to manned spacecraft specification levels using factors from the RCA Price Model. From that model, an average cost factor to adjust MILSPEC to manned spacecraft is around 1.75 for DDT&E and 1.6 for production cost. Under the assumption that some relaxation of Apollo-type specifications can be made for the SPS, a factor of 1.5 was assumed for both DDT&E and production cost. Furthermore, it was assumed that a factor of 3.0 would adjust commercial specifications to SPS requirements. Therefore, military or commercial cost data used in the CERs were adjusted upward by factors of 1.5 and 3.0, respectively.

The cost equations allow a complexity factor input to adjust the cost result when it is determined that the item being estimated is either more or less complex than the listed CER data base.

¹Equipment Specification Cost Effect Study, Phase II Final Report, Nov. 30, 1976, by RCA Government Systems Division



The degree of automation is accounted for in certain cost equations through an adjustment to the CER coefficient by the tooling factors given in Table B-1. The effect of tooling is dependent upon the annual production rate. Higher production rates allow harder tooling and, thus, effect cost reductions. The tooling factors are used only on those CERs which are based on historical aerospace programs with limited annual production rates. Tooling factors are not used on those CERs which are based on data already reflecting automated production techniques (e.g., the commercial electronics data for the microwave antenna CER).

AVERAGE ANNU PRODUCTION R (AAPR)	-	TOOLING FACTOR (TF)	PROGRESS FRACTION (5)
1-2	•	1-0	0.80
3-5		0.9	0.80
6-9		0.8	0.80
10-19	54.1	0.7	0.85
20-39		0.6	0.85
40-69		0.5	0.85
70-109		0.4	0.85
110-159		0.3	0.90
160-219		0.2	0.90
220-999 .		(AAPR) -0 -35	0.90
1000-9999		(AAPR) ⁻⁰ ⋅35	0.95
10,000		(AAPR) -0.35	0.98

Table B-1. SPS Tooling Factors

The decreasing cost effects of progress due to production process improvements or direct labor learning are accounted for through standard progress functions. Many SPS components will be mass produced in a capital intensive manner and will experience little labor learning. Other SPS hardware items, however, will be produced at very low annual rates, much in the labor-intensive manner of historical spacecraft programs, and therefore would experience learning. (Technically distinguishable from learning, but still predictable with the same form of exponential function, are the effects of production process improvement. In this model, when progress functions are used, they are meant to account for both of these effects.) A constant relationship has been assumed between the progress fraction and the annual production rate as given in Table B-1.

As required by the costing ground rules and assumptions, all CERs are in terms of 1977 dollars. The study did assume 1990 technology and 1990 supply/demand conditions which, in some cases, resulted in differential (non-general) price inflation or deflation between 1977 and 1990 being included in the CERs. Specifically, it was assumed that composite raw material prices and some electronic component prices will decrease relative to general prices while aluminum coil stock prices will increase relative to general prices. Such effects are allowed for by the CERs, but only to the extent that the expected price changes differ from expected general price changes. The CERs affected are the antenna structure CER, the power source structure CER, and the microwave antenna CER.

Definitions of SPS cost model terms and equation abbreviations are presented in Table B-2.

Table B-2. Definitions of SPS Cost Model Elements

- COST IN MILLIONS OF 1977 DOLLARS
■ DDT&E COST
- DDT&E COST ESTIMATING RELATIONSHIP (CER)
- DDT&E SCALING EXPONENT
- COST ESTIMATING RELATIONSHIP
- COMPLEXITY FACTOR
= [NITIAL CAPITAL INVESTMENT COST ESTIMATING . RELATIONSHIP (CER)
- INITIAL CAPITAL INVESTMENT COST SCALING EXPONENT
= COST TO BUILD AN ITEM
- INVESTMENT PER SATELLITE COST
- LOWEST REPEATING MODULE COST
- OPERATIONS AND MAINTENANCE COST PER SATELLITE PER YEAR
- REPLACEMENT CAPITAL INVESTMENT COST PER SATELLITE PER YEAR
- THEORETICAL FIRST UNIT COST
- DESIGN, DEVELOPMENT, TEST AND EVALUATION
- DEVELOPMENT FRACTION
= 1.0 + LOG (PHI) ÷ LOG (2.0)
- INITIAL CAPITAL INVESTMENT
- AVERAGE UNIT INVESTMENT COST (2 THRU N)
- MASS, POWER, AREA OF LOWEST REPEATING MODULE
- NUMBER OF REPEATING MODULES
- OPERATIONS
- OPERATIONS AND MAINTENANCE COST PER SATELLITE PER YEAR
= PROGRESS FRACTION
- ANNUAL SPARES FRACTION
= REPLACEMENT CAPITAL INVESTMENT COST PER SATELLITE PER YEAR
TOTAL (MASS. POWER. AREA) PER SATELLITE
- TOOLING FACTOR
= THEORETICAL FIRST UNIT
- TFU REQUIREMENT
= SPS OPTION QUANTITY
= TOTAL SPS REQUIREMENT PER OPTION
= ITEMS NEEDED TO CONSTRUCT SATELLITE OPTION
- ITEMS NEEDED FOR ORM OF THE SATELLITE OPTION

B.3 SPS PROGRAM COST BREAKDOWNS

An overall cost relationship for the SPS program is shown in Figure B-2. Principal areas of SPS costing are represented to indicate the emphasis on expenditures as the program moves from one phase to the next.

Subsequent tables summarize the cost data used in developing Figure B-2. They reflect SPS-related development cost DDT&E (CD) data through the first 5-GW satellite (TFU). Table B-3 includes space construction/support, transportation.

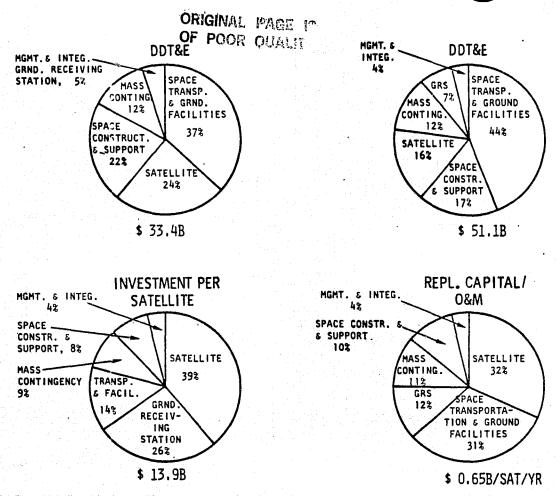


Figure B-2. SPS Cost Relationships

vehicles/operations, and the ground receiving station needed to establish SPS operational capability. This means that the TFU cost includes elements with a lifetime capability of building more than one SPS. Table B-4 summarizes the investment cost per satellite (CIPS) and the replacement capital investment cost (CRCI) plus operations and maintenance (CO&M) per satellite per year.

Table B-3. SPS Program Development Cost

WBS # E	ESCRIPTION		DOTGE	EVELOPMENT TFU	TOTAL
1	SATELLITE POWER SYSTEM (SPS)	PROGRAM	33+01.702	51103.242	84505.000
1.1	SATELLITE SYSTEM		7933.570	7950.922	15894.492
1.2	SPACE CONSTRUCTION & SUPPORT		7331.180	8602.523	15933.703
1.3	TRANSPURTATION		12463.316	22566.199	3533>+016
_1.4	GROUND PECETVING STATION		115.699	3618.727	3734.427
1.9	MANAGEMENT AND INTEGRATION		1392.463	2151.918	3544.382
1.6	MASS CONTINGENCY		4160.031	5912.945	12072.977

Table B-4. SPS Program Average Cost

WaS #	DESCRIPTION	INV PER SAT	## OP5	CUST PEK SA DEM 1	LT PER YEAR TOTAL UPS	** TUTAL
1	SATELLITE PUNER SYSTEM (SPS) PRO	GRAM 13677.008	451.531	193.713	645.244	14522.910
1.1	SATELLITE SYSTEM	5325 . 422	205.265 _	0.705	205.970	5531.391
1.2	SPACE CONSTRUCTION & SUPPORT	1148.332	51.428	11.274	62.701	1211.033
1.3	THANSPURT STILL	1949.00+	119.343	80.509	200.212	2149.216
1.4	GROUND RECEIVING STATION	3590 .622	0.275	78.377	78-652	3669 .474
1.5	MANAGEMENT AND INTEGRATION	600 679	18.815	8.561	27.377	628.055
1.6	MASS CUNTINGENCY	1263 -413	56.405	13.927	70.332	1333.745

B.3.1 DEVELOPMENT COST (DDT&E) AND THEORETICAL FIRST UNIT (TFU)

The total program DDT&E and TFU cost for a first full-up nominal 5-GW SPS system is \$84.5 billion. The DDT&E of \$33.4 billion and the \$51.1 billion for the TFU are detailed by SPS WBS line item in a subsequent table. Detailed DDT&E cost breakdowns show that over 60% of the DDT&E cost is identifiable to transportation and support systems, and the satellite system.

In view of the physical size of the satellite and supportive subsystems and the large quantities required for certain parts and components, it was not considered reasonable to estimate the DDT&E costs as a function of the total mass, area, or power per subsystem—which is generally the method; instead, it was considered desirable to determine the DDT&E costs by application of a development factor (DF). In general, the DF was applied on the basis of a particular system/component in conjunction with the engineering staff and as related to the program development scenario and the usage/availability of the system when needed. For example, the 335-MW EOTV precursor test article is required early in the program for MW verification. The SCB will build this unit first and the DDT&E effort on the many components must be satisfied before items can be made available. Typical items include the structure, concentrators, solar cells, power distribution, and supporting systems that are design verifications of the full-up SPS satellite. As a result of this approach, a 1.0 DF was used on components of the EOTV test article; whereas on other usages of these systems, such as on the EOTV's or similar systems of the satellite itself, a reduced factor was applied in recognition of the earlier completed DDT&E effort. This rationale was also followed in other areas of the SPS program cost analysis.

DDT&E and TFU cost breakdowns are shown in Table B-5. The TFU listing reflects a somewhat different makeup of costs when compared to the DDT&E costs. TFU estimates of \$51.1 billion include the full dollar assessment for an initial satellite and ground receiving station, include space transportation fleets; the LEO, SCB, and support assembly equipment; and the facilities needed to establish a 5-GW SPS operational capability. This means that the TFU cost includes elements with a lifetime capability of servicing/building more than one SPS system. In this regard, analysis will show that transportation and space construction and support equipment represent the largest portion of total TFU costs. However, these systems will be used to construct remaining satellites.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE B-5. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

			DE	VELOPMENT	er ynn hai'r prawnon, progadd y dd'r ros i dlego ddan o'dd -dredd ardi'n ll o'r bllogod bledan dwyn. Hae bregoddogy d	
W	BS # DE	SCRIPTION		DDTGE	TFU	TOTAL
	1	SATELLITE POWER SYSTEM (SPS) PROGRAM		33401.762	51103.242	84505.000
	1.1	SATELLITE SYSTEM		7933.570	7950.922	
	1.1.1				2007.983	
	1.1.1.1	STRUCTURE		71.066	104.608	175.674
	1.1.1.1.1	PRIMARY STRUCTURE		47.821	35.100	82.921
	1.1.1.1.2			23.245	69.508	92.753
	1.1.1.2	CONCENTRATORS		0.0	75.637	75.637
	1.1.1.3	SOLAR BLANKETS		0.0	1651.832	1651.832
	1.1.1.4	POWER DIST. & CONDITIONS	00	46.999	126.986	173.984
	1.1.1.4.1		ORIGINAL OF POOR	3.582	89.123	92.704
	1.1.1.4.2	CONDUCTORS & INSULATION	7. 当	6.234	9.468	15.702
	1.1.1.4.3	SLIP RINGS	0 5	7.392	27.626	35.018
	1.1.1.4.4	BATTERIES	70 -	5.001	0.338	5.339
Ħ	1.1.1.4.5	BATTERY PD&C	O S	24.790	0.430	25.220
9	1.1.1.5	THERMAL CONTROL	PAGE PAGE	0.0	0.0	
	1.1.1.6	MAINTENANCE		0.0	48.921	48.921
	1.1.1.6.1	MAINTENANCE - FREE FLYERS	Ħ 5	0.0	29.299	29.299
	1.1.1.6.2	MANNED MANIPULATOR		0.0	19.203	19.203
	1.1.1.6.3	TRACKS & ACCESS WAYS		0.0	0.420	0.420
	1.1.2	POWER TRANSMISSION		883.144	3816.522	4699.664
	1.1.2.1	STRUCTURE		26.007	49.349	75.356
	1.1.2.1.1	PRIMARY STRUCTURE		7.301	3.350	10.651
	1.1.2.1.2	SECONDARY STRUCTURE		18.705	45.999	64.704
	1.1.2.2	TRANSMITTER SUBARRAYS - KLYSTRONS		102.576	2702.309	2804.885
	1.1.2.2.1	KLYSTRON DOTEE		102.576	0.0	102.576
	1.1.2.2.2	KLYSTRON ICI, R, DEM		0.0	2702.309	2702.309
the second of the second of	1.1.2.3	POWER DIST. & CONDITIONING		12.393	769.800	782.193
	1.1.2.3.1	SWITCH GEAR & CONVERTERS		7.132	752.336	759.468
	1.1.2.3.2	CONDUCTORS & INSULATION .		5.262	5.348	10.610
	1.1.2.3.3	BATTERILS		0.0	12.115	12.115
	1.1.2.4	THERMAL CUNTROL - INSULATION		29.136	208.002	237.198
	1.1.2.5	CONTRUL - PHASE REFERENCE		0.373	20.050	20.423
	1.1.2.5.1			0.100	0.100	0.200
	1.1.2.5.2	DIST. SYSTEM, COAXIAL CABLE		0.203	12.180	12.383
	1.1.2.5.3	DIST. SYSTEM, DEVICES		0.070	7.770	7.840

RUCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE B-5. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

		DEV	ELOPMENT	The continue of the continue o
WBS # DE	SCRIPTION	DDT&E	TFU	TOTAL
1.1.2.6	MAINTENANCE	712.660	66.953	779.613
1.1.2.6.1	MAINTENANCE - FREE FLYERS	0.0	36.368	36.368
1.1.2.6.2	GANTRY CRANE	91.060		91.280
1.1.2.6.3		621.600	30.305	651.905
1.1.2.6.4	TRACKS & ACCESS WAYS	0.0	0.060	0.060
1.1.3	INFORMATION MGMT. & CONTROL	72,565	196,897	269.462
1.1.3.1	MASTER CUNTROL COMPUTER	16.127	7.845	23.972
1.1.3.2	DISPLAYS & CONTROLS	10.745	1.211	11.956
1.1.3.3	SUPERVISORY COMPUTER	2.753	2.325	5.078
1.1.3.4	REMOTE COMPUTER	2.643	5.696	8.339
1.1.3.5	BUS CONTROL UNIT	0.415	6.940	7.354
1.1.3.6	MICROPROCESSORS	0.431	6.881	7.312
1.1.3.7	REMOTE ACQUISITION & CUNTROL	0:414	7.450	7.864
1.1.3.8	SUBMULTIPLEXORS	0.266	66.119	66.385
۳ 1.1.3.9	INSTRUMENTATION	28.000	74.192	102.192
당 1.1.3.10	OPTICAL FIBER	0.807	0.634	1.442
1.1.3.11	CABLES/HARNESS	9.963	17.604	27.567
1.1.4	ATTITUDE CONTROL & STATIONKEEPING	8.183	72,488	80.671
1.1.4.1	ACSS HARDWARE	8.183	72.488	80.671
1.1.4.2	ACSS PROPELLANT	0.0	0.0	0.0
1.1.5	COMMUNICATIONS	0.0	0.0	0.0
1.1.5.1	SATELLITE TO GROUND	0.0	0.0	0.0
1.1.5.2	SATELLITE TO RESUPPLY VEHICLES	0.0	0.0	0.0
1.1.5.3	SATELLITE INTERCOM	0.0	0.0	0.0
1.1.6	INTERFACE	56.309	118.560	174.869
1.1.6.1	STRUCTURE	35.115	76.827	111.942
1.1.0.1.1	PRIMARY STRUCTURE	11.638	6.000	17.638
	SECONDARY STRUCTURE	23.476	70.827	94.303
1.1.6.2	MECHANISMS - INTERFACE	15.225	7.878	23.103
1.1.6.3	POWER DISTRIBUTION	5.969	7.003	12.972
1.1.6.3.1		5.178	5.068	10.246
1.1.6.3.2		0.791	1.935	2.726
1.1.0.4	THERMAL CONTROL	0.0	0.0	0.0
1.1.6.5	MAINTENANCE	H 49	20.852	26 • 8 52
1.1.6.5.1	MAINTENANCE - FREE FLYERS	0.0	7.530	7.530

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE B-5. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

	ne	VELOPMENT	
A DOCUMENT OF CONTRACTOR	DDT&E	TFU	TOTAL
WBS # DESCRIPTION	טטועב	1 FU	IUIAL
1.1.6.5.2 MANNED MANIPULATOR	0.0	19.203	19.203
1.1.6.5.3 TRACKS & ACCESS WAYS	0.0	0.120	0.120
1.1.7 SYSTEMS TEST	5325.422	0.0	5325.422
1.1.7.1 SYSTEM GROUND TEST HARDWARE	2662.711	0.0	2662.711
1.1.7.2 SYSTEM GROUND TEST OPERATIONS	2662.711	0.0	2662.711
1.1.8 GROUND SUPPORT EQUIPMENT	721.234	0.0	721,234
1.1.9 COTV - PRECURSOR	748.653	1738.474	2487.127
1.1.9.1 COTY PRECURSOR VEHICLE	748.653	1737.844	2486.497
1.1.9.1.1 PRIMARY STRUCTURE - E.C.	89.863	1.544	91.408
1.1.9.1.1 PRIMARY STRUCTURE - E.C. 1.1.9.1.2 SECONDARY STRUCTURE - E.C. 1.1.9.1.3 CONCENTRATOR - E.C.	21.178	533.576	554.754
1.1.9.1.3 CONCENTRATOR - E.C.	7.869	2.817	10.686
	47.041	60.300	107.341
1.1.9.1.5 SWITCHGEAR & CONVERTERS -E.C. 1.1.9.1.6 CONDUCTORS & INSULATION - E.C.	3.497	1.725	5.222
1.1.9.1.6 CONDUCTORS & INSULATION - E.C.	7.048	1.431	8.478
₩ 1.1.9.1.7 ACS HARDWARE - E.C.	12.190	620.634	632.823
# 1.1.9.1.7 ACS HARDWAKE - E.C. E 1.1.9.1.8 SLIPRINGS - PRECURSOR < 3	54.565	30.980	85.546
1.1.9.1.9 PRIMARY STRUCTURE - INTERFACE	152.844	6.000	158.844
1.1.9.1.10 SECONDARY STRUCTURE - INTERFACE	15.155	4.047	19.202
1.1.9.1.11 MECHANISMS - INTERFACE	78.868	221.647	300.514
1.1.9.1.12 CONDUCTORS & INSULATION	3.993	0.211	4.204
1.1.9.1.13 SLIPRING BRUSHES - PRECURSOR	2.529	2.268	4.797
1.1.9.1.14 PRIMARY STRUCTURE - POWER TRANS	20.936	0.250	21.186
1.1.9.1.15 SECONDARY STRUCTURE - POWER TRANS	17.041	2.546	19.587
1.1.9.1.16 TRANSMITTER SUBARKAYS - KLYSTRONS ICI	0.0	141.497	141.497
1.1.9.1.17 SWITCHGEAR & CONVEKTERS - P.T. PRECURSOR	6.756	47.520	54 • 276
1.1.9.1.18 CONDUCTORS & INSULATION - P.T. PRECURSOR	4.147	0.240	4.387
1.1.9.1.19 BATTERIES - P.T. PRECURSOR	27.106	11.501	
1.1.9.1.20 THERMAL CONTROL - INSULATION - PRECURSOR	26.539	45.996	72.535
1.1.9.1.21 REFERENCE FREQUENCY GENERATOR - PRECURSOR	0.500	0.100	0.600
1.1.9.1.22 DIST. SYSTEM, COAXIAL CABLE	0.258	0.517	0.775
1.1.9.1.23 DIST. SYSTEM DEVICES	0.622	0.500	0.522
1.1.9.1.24 TRANSMITTER SUBARRAYS - KLYSTRONS DOTEE	148.707	0.0	148.707
1.1.9.2 COTY PRECURSUR OPERATIONS	0.0	0.630	0.630
1.2 SPACE CUNSTRUCTION & SUPPORT	7331.180	8602.523	15933.703
1.2.1 CONSTRUCTION FACILITIES	3653 • 249	6575.176	10228.422
1997年,1998年,1997年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1998年,1			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 8-5. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

		DEVELOPMENT			
	WBS # DE	SCR1PTION CONTRACTOR OF THE SECOND CONTRACTOR	DDT&E	TFU	TOTAL
	1.2.1.1	WORK SUPPORT FACILITIES	3092.417	3956.069	7048.484
	1.2.1.1.1	BEAM MACHINE	2.000	83.150	85.150
	1.2.1.1.2	BEAM MACHINE CASSETTES	0.800		7.115
	1.2.1.1.3	CABLE ATTACHMENT MACHINE	4.300	28.228	32.528
	1.2.1.1.4	REMOTE MANIPULATOR	6.880	60.390	67.270
	1.2.1.1.5	BLANKET DISPENSER MACHINE	4.000	26.154	30.154
		SULAR BLANKET CASSETTES	0.800	9.076	9.876
	1.2.1.1.7	REFLECTOR DISPENSER MACHINE	6.000	4.651	10.651
	1.2.1.1.8	REFLECTOR CASSETTES	1.000	2.721	3.721
	1.2.1.1.9	CABLE/CATENARY DISPENSER MACHINES	2.200	22.786	24.986
	1.2.1.1.10	ANTENNA PANEL INS. EQPT.	80.000	200.272	280.272
	1.2.1.1.11	GANTRY/CRANES CONTROLLER CONTROLL	13,600	85.034	98.634
:	1.2.1.1.12	CARGO STORAGE DEPUTS	12.000	7.559	
	1.2.1.1.13	FAB FIXTURE	2165.128	82.445	
tel	1.2.1.1.14	AIRLOCK DOCKING MODULE (ADM)	0.0		242.302
β <u>-</u>	1.2.1.1.15	BASE MGMT. MODULE (6MM)	0.0	1213.870	1213.870
[2]	1.2.1.1.16	POWER MODULE (PM)	0.0	1075.459	1075.459
	1.2.1.1.17	PRESSURIZED STORAGE MODULE (PSM)	793.710	805.657	1599.367
	1.2.1.2	CREW SUPPORT FACILITIES-SCB	560.832	2590.290	3151.122
	1.2.1.2.1	AIRLOCK DOCKING MODULE-ADM	31.152	73.413	104.565
	1.2.1.2.2	CREW HABITABILITY MODULE-CHM	0.0	1634.456	1634 • 456
	1.2.1.2.3	CONSUMABLES LOGISTICS MODULE-CLM	0.6	604.675	604.675
	1.2.1.2.4	SHIELDING	343.200	21.160	364.360
	1.2.1.2.5	CREW SUPPURT MODULE-CSM	186.480	256.587	443.067
	1.2.1.3	OPERATIONS	0.0	28.819	28.819
	1.2.1.3.1	OPERATIONS, CONSTRUCTION CREW	0.0	19.781	19.781
	1.2.1.3.2	ORBITAL OPERATIONS, CONST. PROV.	0.0	9.038	
	1.2.2	LOGISTICS SUPPORT FACILITIES-LED	3677.934	917.151	4595.082
	1.2.2.1	WORK SUPPORT FACILITIES	2814.992	586.187	3401.179
	1.2.2.1.1	BASE MGMT. MODULE-BMM	2464.993	310.814	2775.806
		POWER MODULE-PM	350.000	275.373	625.373
	1.2.2.2	CREW SUPPORT FACILITIES	362.942	328.782	1191.724
		CREW HABITABILITY MODULE-CHM	262.278	101.928	364.206
		CONSUMABLES LOGISTICS MODULE	265.000	70.095	335.095
	1.2.2.2.3	CREW SUPPORT MODULE/EVA	335.664	156.759	492.423

RUCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE B-5. SATELLITE POWER SYSTEM (SPS) PROGRAM DEVELOPMENT COST

			and the second s	DEV	VE LOPMENT	an included in and to be an investigation of the included in the included in the second section of the second
h	VES # DE	SCRIPTION		DOTRE	TFU	TOTAL
				0.0	2.182	2.182
	1.2.2.3	OPERATIONS	Maria de Carlos Habertos (1939) Para de La Carlos (1939)	0.0	1.498	1.498
	1.2.2.3.1	LEO OPERATIONS CREW			0.684	0.684
	1.2.2.3.2	LEO CREW PROVISIONS		0.0	1110.198	1110.198
	1.2.3	OEM SUPPORT FACILITIES - SATELLITE		0.0	763.578	763.578
	1.2.3.1	WORK SUPPORT FACILITIES		0.0	44.520	44.520
	1.2.3.1.1	AIRLOCK DOCKING MODULE-ADM		0.0	310.814	310.814
	1.2.3.1.2	BASE MGMT MODULE-BMM		0.0		408.244
	1.2.3.1.3	PRESSURIZED STORAGE MCDULE-PSM		0.0	408.244	
	1.2.3.2	CREW SUPPORT FACILITIES		0.0	343.893	343.893 15.111
	1.2.3.2.1	AIRLOCK DOCKING MODULE-ADM	ÖRİĞINAL OF POOR	0.0	15.111 101.928	101.928
	1.2.3.2.2	CREW HABITABILITY MODULE-CHM	ના <u>છે</u>	0.0	70.095	70.095
	1.2.3.2.3	CONSUMABLES LOGISTICS MODULE-CLM	- ÇZ	0.0	156.759	156.759
	1.2.3.2.4	CREW SUPPORT MODULE/E VA	`	0.0		2.727
	1.2.3.3	OPERATIONS		0.0	2.727 1.872	1.872
	1.2.3.3.1	SATELLITE OPERATIONS CREW	27	0.0	0.855	0.855
		SATELLITE CREW PROVISIONS	AGE	0.0		35335.016
13	1.3	TRANSPORTATION	7 6	12468.816	22866.199 9530.492	18130.492
	1.3.1	SPS-HEAVY LIFT LAUNCH VEHICLE (HLLV)	≺ <u>v</u>	8600.000 8600.000	8950.176	17550.176
	1.3.1.1	SPS-HLLV FLEET			580.320	580.320
	1.3.1.2	SPS-HLLV OPERATIONS		0.0 31.818	3625.720	3657.538
	1.3.2	CARGO ORBITAL TRANSFER VEHICLE(COTV)		31.010	3621.310	3653.128
	1.3.2.1	COTV VEHICLES		3.930	9.267	13.197
	1.3.2.1.1	PRIMARY STRUCTURE			2478.750	2483.332
	1.3.2.1.2	SECONDARY STRUCTURE		4.582 1.685	15.818	17.503
	1.3.2.1.3	CONCENTRATOR		7.664	338.117	345.781
	1.3.2.1.4	SOLAR BLANKET		2.054	8.760	10.814
	1.3.2.1.5	SWITCHGEAR AND CONVERTERS		2.205	8.584	10.789
	1.3.2.1.6	CONDUCTORS AND INSULATION		9.697	762.015	771.712
	1.3.2.1.7	ACS HARDWARE		0.0	0.0	0.0
	1.3.2.1.8	INFO. MGMT. AND CONTROL		0.0	4.410	4.410
	1.3.2.2	COTY OPERATIONS		1549.000	6251.230	7800.230
	1.3.3	PERSONNEL LAUNCH VEHICLE(PLV)		1549.000	3908.082	5457.082
	1.3.3.1	STS-PLV FLEET		0.0	1682.531	1682.531
	1.3.3.1.1	STS-PLV ORBITER		0.0	606.205	606.205
	1.3.3.1.2	STS-PLV EXTERNAL TANK			000.200	000 • 200

			DEV	ELOPMENT	· · · · · · · · · · · · · · · · · · ·	
	WBS # DE	SCRIPTION	DDTEE	TFU	TOTAL	j
~	1.3.3.1.3	STS-PLV LIW. ROCKET BOOSTER	1304.000	873.985	2177.985	
	1.3.3.1.4	STS CARGO CARRIER AND EM	245.000	745.362	990.362	
	1.3.3.2	PLV & STS-HLLV OPERATIONS	0.0	2343.150	2343.150	j
	1.3.3.2.1	PLV OPERATIONS	0.0	1214.400	1214.400	
	1.3.3.2.2	STS HLLV CARGO UPERATIONS	0.0	1128.750	1128.750	Ì
	1.3.4	PERSONNEL ORBITAL TRANS VEHICLE	350.000	56.282	406.282	
<u>-</u>	1.3.4.1	POTV-FLEET	350.000	54.764	404.764	
	1.3.4.2	POTV-OPERATIONS	0.0	1.518	1.518	
	1.3.5	PERSONNEL MODULE(PM)	118.000	201.910	319.910	ţ
	1.3.5.1	PM FLEET	118.000	198.610	316.610	and the supplemental to th
	1.3.5.2	PM OPERATIONS	0.0	3.300	3.300	
	1.3.6	INTRAORBITAL TRANSFER VEHICLE (IOTV)	100.000	5.567	105.567	
	1.3.6.1	IOTV FLEET	100.000	5.476	105.476	
	1.3.6.2	IOTY OPERATIONS	0.0	0.091	0.091	
. i-el	1.3.7	GROUND SUPPORT FACILITIES	1720.000	3195.000	4915.000	
B-14	1.3.7.1	LAUNCH FACILITIES	0.0	0.C	0.0	
4	1.3.7.2	RECOVERY FACILITIES	0.0	0.0	0.0	
	1.3.7.3	FUEL FACILITIES		0.0	0.0	
······································	1.3.7.4	LOGISTICS SUPPORT	0.0	0.0	0.0	
	1.3.7.5	OPERATIONS	0.0	0.0	0.0	
	1.4	GROUND RECEIVING STATION	115.699	3618.727	3734.427	
	1.4.1	SITE AND FACILITIES	1.000	195.197	196.197	
	1.4.1.1	LAND AND PREPARATION	0.0	105.341	105.341	(
	1.4.1.1.1	L'AND TO THE STREET OF THE STR	0.0	35.000	35.000	
	1.4.1.1.2	LAND PREPARATION	0.0	70.341	70.341	1
	1.4.1.2	ROADS AND FENCES	0.0	74.180	74.180	
	1.4.1.2.1	RAILS AND RUADS	0.0	73.710	73.710	
	1.4.1.2.2	FENCING	0.0	0.470	0.470	.,
	1.4.1.3	UTILITIES		0.200	0.200	
	1.4.1.4	BUILDINGS	0.0	11.477	11.477	
	1.4.1.4.1	STORAGE, MAINTENANCE	0.0	1.300	1.300	i
	1.4.1.4.2	CUNV. STA. & MONITOR/CONTROL FAC.		10.177	10.177	
	1.4.1.5	MAINTENANCE EQPT.	5.0	4.000	4.000	
	1.4.1.6	LIGHTNING PROTECTION		0.0	0.0	ļ
	1.4.1.7	SITE & FACILITIES DDT&E	1.000	0.0	1.000	

			DEV	ELOPMENT		
	WBS # DE	SCRIPTION	DDTEE	TFU	TOTAL	
	1.4.2	RECTENNA SUPPORT STRUCTURE	2.000	1849.629	1851.629	
	1.4.2.1	STEEL PANEL FAB. & INSTALLATION	0.0	1696.508	1696.508	
	1.4.2.1.1	HAT SECTIONS	: 0.0	359.228	359.228	
	1.4.2.1.2	WIDE FLANGES	0.0	295.173	295.173	
	1.4.2.1.3	TUBE BRACES & HARDWARE	0.0	431.346	431.346	
	1.4.2.1.4	ASSEMBLY & INSTALLATION	0.0	610.762	610.762	
	1.4.2.2	TRENCHING & CONCRETE INSTALLATION	0.0	153.121	153.121	
	1.4.2.2.1	FOOTING CONCRETE & RE-BAR	0.0	70.821	70.821	
	1.4.2.2.2	MACHINGERY & EQUIPMENT	0.0	22.360	22.360	
	1.4.2.2.3	CONSTRUCTION OPERATIONS	0.0	59.940	59.940	
	1.4.2.3	SUPPORT STRUCTURE DDT&E	2.000	0.0	2.000	
	1.4.3	POWER CULLECTION	3.000	1353.211	1356.211	
	1.4.3.1	ANTENNA ARRAY ELEMENTS POWER DISTRIBUTION SYSTEM INSTALLATION & CHECKOUT POWER COLLECTION-DOT&E CONTROL	14 A (1127.331	1127.331	
	1.4.3.2	POWER DISTRIBUTION SYSTEM	0.0	69.660	69.660	
₩	1.4.3.3	INSTALLATION & CHECKOUT	0.0	156.220	156.220	
15	1.4.3.4	POWER COLLECTION-DOTE E	3.000	0.0	3.000	
	1.4.4	U 1 DV 1 7 1 1 1	10.006	75.000	85.000	
	1.4.4.1	CONTROL CENTER EQUIPMENT	0.0	15.000	15.000	
	1.4.4.2	CONTROL ELECTRONICS CONTROL UDT&E GRID INTERFACE	0.0	60.000	60.000	
	1.4.4.3	CONTROL UDTEE	10.000	0.0	10.000	
	1.4.5		99.699	145.690	245.389	
	1.4.5.1	ELECTRICAL EQUIPMENT	0.0	145.690	145.690	
	1.4.5.2	GRID INTERFACE-DDT&E	99.699	0.0	99.699	
	1.4.6	<u>OPERATIONS</u>	0.0	0.0	0.0	
	1.4.6.1	OPER. & MAINT. PERSONNEL	0.0	0.0	0.0	
	1.4.6.2	MAINT. MATERIAL	0.0	0.0	0.0	
	1.5	MANAGEMENT AND INTEGRATION	1392.463	2151.918	3544.382	
	1.6	MASS CONTINGENCY	4160.031	5912.945	10072.977	

B.3.2 INVESTMENT AND OPERATIONS

Detailed investment and RCI/O&M cost data are shown in Table B-6. Investment costs were developed at two levels:

- (1) Initial capital investment (ICI), which is the cost of production, assembly, installation, transportation, and tests of each individual satellite produced, and the ground station system and associated effort necessary to bring the power satellite on line to a 5-GW operational capability.
- (2) Replacement capital investment (RCI), which are those expenditures relating to capital asset replacement and major maintenance overhauls/spares that are expected to last for more than one year or result in an improvement to the operating system.

Costs for the transportation fleet needed to construct the satellites are included in the ICI; whereas, the fleet required for O&M of the satellite over the 30 years is included in the O&M cost. Replacement capital investment is included in the RCI column.

Investment per satellite is equivalent to the average unit cost of the total SPS requirement—TFU plus satellites and supporting program elements for the 60-SPS option. Total average ICI cost is projected at \$13.9 billion. Annual SPS estimates are placed at \$0.45 billion for RCI and \$0.20 billion for O&M.

wBS # DE	SCRIPTION	NV PER SAT	** UPS (RC1	OST PER SA	T PER YEAR OTAL OPS	** TOTAL
1	SATELLITE POWER SYSTEM (SPS) PROGRAM	13877.668	451.531	193.713	645-244	14522.910
1.1	SATELLITE SYSTEM	5325 • 422	205.265	0.705	205.970	5531.391
1.1.1	ENERGY CONVERSION	1851 .622	4.500		4.510	
1.1.1.1	STRUCTURE	96.789	0.194	0.0	0.194	96.983
1.1.1.1.1	PRIMARY STRUCTURE	35.100	0.070	0.0	0.070	35.170
1.1.1.1.2	SECONDARY STRUCTURE	61.689	0.123	0.0	0.123	61.812
1.1.1.2	CONCENTRATORS	67.183	0.134	0.0	0.134	67.318
1.1.1.3	COL AD DE AND STE	1556 . 692	3.113	0.0	3.113	1559.805
1.1.1.4	DOUGD DIST C COMPLETIONS 23	91.948	0.169	0.010	0.179	92.127
1.1.1.4.1	SWITCH GEAR & CONVERTERS 7 9	66.093	0.0	0.0	0.0	66.093
1.1.1.4.2	CONDUCTORS & INSULATION 23	9.468	0.0	0.0	0.0	9.468
1.1.1.4.3	SLIP RINGS	15.825	0.158_	0.0	0.158	15,983
1.1.1.4.4	BATTERIES BATTERY PD&C THERMAL CONTROL	0.238	0.008	0.010	0.018	9.256
1.1.1.4.5	BATTERY PD&C	0.324	0.003	0.0	0.003	0.327
1.1.1.5	THERMAL CONTROL	0.0	0.0	0.0	0.0	
% l.1.1.6	MAINTENANCE TO	39.010	0.890	0.0	0.890	39.899
1.1.1.6.1	MAINTENANCE - FREE FLYERS	23.392	0.585	0.0	0.585	23.977
71.1.1.6.2	MANNED MANIPULATOR	15.198	0.304	0.0	0.304	15.502
1.1.1.6.3	TRACKS & ACCESS WAYS	0.420	0.001	0.0	0.001	0.421
1.1.2	POWER TRANSMISSION	3153.938	197.438	0.485	197.923	3351.861
1.1.2.1	STRUCTURE	44.175	0.088	0.0	0.088	44.263
1.1.2.1.1		3.350	0.007	0.0	0.007	3.357
1.1.2.1.2	SECONDARY STRUCTURE	40.825	0.092	0.0	0.082	40.906
1.1.2.2	TRANSMITTER SUBARKAYS - KLYSTRONS	2322.864	154.854	0.0	154.854	2477.658
1.1.2.2.1	KLYSTRON DDT&E	0.0	0.0	0.0	0.0	0.0
1.1.2.2.2	KLYSTRON ICI, R, O&M	2322.804	154.854	0.0	154.854	2477.658
1.1.2.3	POWER DIST. & CONDITIONING	526 • 406	34.454	0.475	34.929	561.334
1.1.2.3.1	SWITCH GEAR & CONVERTERS	512.556	34.171	0.0	34.171	546.726
1.1.2.3.2	CONDUCTORS & INSULATION .	5.348	0.0	0.0	0.0	5.348
1.1.2.3.3	BATTERIES	8.502	0.283	0.475	0.758	9.261
1.1.2.4	THERMAL CUNTROL - INSULATION	184.657	1.847	0.0	1.847	186.504
1.1.2.5	CONTROL - PHASE REFERENCE	20.050	0.262	0.010	0.272	20.322
1.1.2.5.1	REFERENCE FREQUENCY GENERATOR	0.100	0.003	6.010	0.013	0.113
1.1.2.5.2	DIST. SYSTEM, COAXIAL CABLE	12.180	0.0	0.0	0.0	12.180
1.1.2.5.3	DIST. SYSTEM, DEVICES	7.770	0.259	0.0	0.259	8.029

		*** *** *** *** *** *** *** *** *** **	** OPS C	OST PER SAT	PER YEAR	** TOTAL
MR2 # DE	SCRIPTION	INV PER SAT	RCI	OEM TO	OTAL OPS	
1.1.2.6	MAINTENANCE	55.846	5.933	0.0	5.933	61.779
1.1.2.6.1	MAINTENANCE - FREE FLYERS	28.784	0.576	0.0	0.576	29.360
1.1.2.6.2	GANTRY CRANE	0.220	0.000	0.0	0.000	0.220
1.1.2.0.3	UN-CRANE CONTROL CENTER	26.782	5.356	0.0	5.356	32.139
1.1.2.6.4	TRACKS & ACCESS WAYS	0.060	0.000	0.0	0.000	0.060
1.1.3	INFORMATION MGMT. & CONTROL	163.189	1.632	0.0	1.632	164.821
1.1.3.1	MASTER CONTROL COMPUTER	2.659	0.027	0.0	0.027	2.685
1.1.3.2	DISPLAYS & CONTROLS	0.453	0.005	0.0	0.005	0.458
1.1.3.3	SUPERVISORY COMPUTER	0.969	0.010	0.0	0.010	0.979
1.1.3.4	REMOTE CUMPUTER	2.238	0.022	0.0	0.022	2.260
1.1.3.5	BUS CONTROL UNIT	5.128	0.051	00	0.051	5.179
1.1.3.6	MICROPROCESSORS	5.085	0.051	0.0	0.051	5.136
1.1.3.7	REMOTE ACQUISITION & CONTROL	5.505	0.055	0.0	0.055	5.560
1.1.3.8	SUBMULTIPLEXORS	58.682	0.587	0.0	0.587	59.268
1.1.3.9	INSTRUMENTATION	65 • 846	0.658	0.0	0.658	66.504
1.1.3.10	OPTICAL FIBER	0.578	0.006	0.0	0.006	0.584
₩ 1.1.3.11	CABLES/HARNESS	16.047	0.160	0:0	0.160	16.207
1.1.4	ATTITUDE CONTROL & STATIONKEEPING	53.746	0.537	0.132	0.669	54.416
1.1.4.1	ACSS HARDWARE	53.746	0.537	0.047	0.584	54.330
1.1.4.2	ACSS PROPELLANT	0.0	0.0	0.085	0.085	0.085
1.1.5	COMMUNICATIONS	0.0	0.0	0.0	0.0	0.0
1.1.5.1	SATELLITE TO GROUND	0.0	0.0	0.0	0.0	0.0
1.1.5.2	SATELLITE TO RESUPPLY VEHICLES	0.0	0.0	0.0	0.0	0.0
1.1.5.3	SATELLITE INTERCOM	0.6	0.0	0.0	0.0	0.0
1.1.6	INTERFACE	102.929	1.157	0.078	1.235	104.163
1.1.6.1	STRUCTURE	68.800	0.138	0.0	0.138	68.998
1.1.6.1.1	PRIMARY STRUCTURE	6.000	0.012	0.0	0.012	6.012
1.1.6.1.2	SECONDARY STRUCTURE	62.860	0.126	0.0	0.126	62.986
1.1.6.2	MECHANISMS - INTERFACE	5.821	0.058	0.078	0.136	5.958
1.1.0.3	PUWER DISTRIBUTION	6.510	0.014	0.0	0.014	6.524
1.1.6.3.1	CONDUCTOR & INSULATION	5.068	0.0	0.0	0.0	5.068
1.1.6.3.2	SLIP RING BRUSHES	1.442	0.014	0.0	0.014	1.456
1.1.6.4	THERMAL CONTROL	0.0	0.0	0.0	0.0	0.0
1.1.6.5	MAINTENANCE	21.738	0.946	0.0	0.946	22.684
1.1.6.5.1	MAINTENANCE - FREE FLYERS	6.420	0.642	0.0	0.642	7.062

WBS # DESCRIPTION	INV PER SAT	RCI		T PER YEAR OTAL UPS	** TOTAL
1.1.6.5.2 MANNED MANIPULATOR	15.198	0.304	0.0	0.304	15.502
1.1.6.5.3 TRACKS & ACCESS WAYS	0.120	0.000	0.0	0.000	0.120
1.1.7 SYSTEMS TEST	0.0	0.0	0.0	0.0	0.0
1.1.7.1 SYSTEM GROUND TEST HARDWARE	9 0.0	0.0	0.0	0.0	0.0
1.1.7.2 SYSTEM GROUND TEST & ERATIONS	6 0.0	0.0	0.0	0.0	0.0
1.1.5 GROUND SUPPORT EQUIPMENT	ORIGIN	0.0	0.0	0.0	0.0
1.1.9 COTV - PRECURSOR	P 0.0	0.0	0.0	0.0	0.0
		0.0	0.0	0.0	0.0
1.1.9.1.1 PRIMARY STRUCTURE - E.C.	PAGE 19	0.0	0.0	0.0	0.0
1.1.9.1.2 SECONDARY STRUCTURE - E.C.	0.0	0.0	0.0	0.0	0.0
1.1.9.1.3 CONCENTRATOR - E.C.	0.0	0.0	0.0	0.0	0.0
1.1.9.1.4 SOLAR BLANKET -E.C.	₹ 0.0	0.0	0.0	0.0	0.0
1.1.9.1.5 SWITCHGEAR & CONVERTERS -E.C.	0.0	0.0	0.0	0.0	€.0
1.1.9.1.6 CONDUCTORS & INSULATION - E.C.	0.0	0.0	0.0	0.0	0.0
# 1.1.9.1.7 ACS HARDWARE - E.C.	0.0	0.0	0.0	0.0	0.0
1.1.9.1.8 SLIPRINGS - PRECURSOR	0.0	0.0	0.0	0.0	0.0
1.1.9.1.9 PRIMARY STRUCTURE - INTERFACE	0.6	0.0	0.0	0.0	0.0
1.1.9.1.10 SECONDARY STRUCTURE - INTERFACE	0.0	0.0	0.0	0.0	0.0
1.1.9.1.11 MECHANISMS - INTERFACE	0.0	0.0	0.0	0.0	0.0
1.1.9.1.12 CONDUCTORS & INSULATION	0.0	0.0	0.0	0.0	0.0
1.1.9.1.13 SLIPRING BRUSHES - PRECURSOR	0.0	0.0	0.0	0.0	0.0
1.1.9.1.14 PRIMARY STRUCTURE - POWER TRANS	0.0	0.0	0.0	0.0	0.0
1.1.9.1.15 SECONDARY STRUCTURE - POWER TRANS	0.0	0.0	0.0	0.0	. 0.0
1.1.9.1.16 TRANSMITTER SUBARKAYS - KLYSTRONS I	C 0.0	0.0	0.0	0.0	0.0
1.1.9.1.17 SWITCHGEAK & CONVERTERS - P.T. PREC	U 0.0	0.0	0.0	0.0	0.0
1.1.9.1.18 CONDUCTORS & INSULATION - P.T. PREC	U 0.0	0.0	0.0	0.0	0.0
1.1.9.1.19 BATTERIES - P.T. PRECURSOR	0.0	0.0	0.0	0.0	0.0
1.1.9.1.20 THERMAL CONTROL - INSULATION - PREC	U 0.0	0.0	0.0	0.0	0.0
1.1.9.1.21 REFERENCE FREQUENCY GENERATOR - PRE	C 0.0	0.0	00	0.0	0.0
1.1.9.1.22 DIST. SYSTEM, COAXIAL CABLE	0.0	0.0	0.0	0.0	0.0
1.1.9.1.23 DIST. SYSTEM DEVICES	0.0	0.0	0.0	0.0	0.0
1.1.9.1.24 TRANSMITTER SUBARRAYS - KLYSTRONS D		0.0	0.0	0.0	0.0
T.1.9.2 COTY PRECURSOR OPERATIONS	0.0	0.0	9.0	0.0	0.0
1.2 SPACE CONSTRUCTION & SUPPORT	1148.332	51.428	11.274	62.701	1211.033
1.2.1 CONSTRUCTION FACILITIES	123.606	19.081	11.274	30.355	153.961

		and the second s	** OPS C	OST PER SA	T PER YEAR	** TOTAL
WBS # DI	SCRIPTION	INV PER SAT	RCI	T M30	OTAL OPS	
1.2.1.1	WORK SUPPORT FACILITIES	66 • 025	13.784	11.274	25.057	91.083
1.2.1.1.1		1.386	0.0	0.594	0.594	1.950
	BEAM MACHINE CASSETTES	0.097	0.000	0.090		0.188
1.2.1.1.3		0.470	0.0	0.144	0.144	0.614
1.2.1.1.4		0.987	0.936	1.925	1.961	2.948
	BLANKET DISPENSER MACHINE	0.436	0.0	0.180	0.180	0.616
1.2.1.1.6		0.273	0.000	0.115	0.116	0.389
1.2.1.1.7		0.078	0.0	0.048		0.126
	REFLECTOR CASSETTES	0.042	0.001			
	CABLE/CATENARY DISPENSER MACHINES		0.0	0.168		
1.2.1.1.10	ANTENNA PANEL INS. EUPT.	3.338	0.0		6.755	10.093
1.2.1.1.1	L GANTRY/CRANES	1.417	0.0	0.600		2.017
1.2.1.1.1	2 CARGO STURAGE DEPUTS	0.126	0.0	0.600	0.600	0.726
	B FAB FIXTURE	1.374	0.0	0.0	0.0	1.374
1.2.1.1.1	AIRLOCK DOCKING MODULE (ADM)	4.038	0.285	0.0	0.285	
1.2.1.1.1	BASE MGMT. MODULE (BMM)	20.231	6.069	0.0	6.069	
₩ 1.2.1.1.16	5 POWER MODULE (PM)	17.924	5.377	0.0	5.377	23.302
No 1.2.1.1.1	7 PRESSURIZED STORAGE MODULE (PSM)	13.428	2.014	0.0	2.014	15.442
1.2.1.2		43.171	5.297	0.0	5.297	48.469
1.2.1.2.1	AIRLOCK DOCKING MODULE-ADM CREW HABITABILITY MODULE-CHM	1.224	0.294	0.0	0.294	1.517
			1.923	0.0	1.923	29.164
1.2.1.2.3		10.078	1.344	0.0	1.344	11.422
1.2.1.2.4		0.353	0.026	0.0	0.026	0.379
1.2.1.2.5		4.276	1.711	0.0	1.711	5.987
1.2.1.3	OPERATIONS	14.410	0.0	0.0	0.0	14.410
1.2.1.3.1	OPERATIONS, CONSTRUCTION CREW	9.890	0.0	0.0	0.0	9.890
1.2.1.3.2		4.519	0.0	0.0	0.0	4.519
1.2.2	LOGISTICS SUPPORT FACILITIES-LEO	16.340	18.299	0.0	18.299	34.640
1.2.2.1	WORK SUPPORT FACILITIES	9.770	11.724	0.0	11.724	21.494
. 1.2.2.1.1	Control of the second	5.180	6.216	0.0	6.216	11.397
1.2.2.1.2		4.590	5.507	0.0	5.507	10.097
1.2.2.2	CREW SUPPORT FACILITIES	5 • 4 60	6.576	0.0	6.576	12.055
	CREW HABITABILITY MUDULE-CHM	1.699	the company of the co		2.039	
1.2.2.2.2	CONSUMABLES LOGISTICS MODULE	1.168	1.402	0.0	1.402	2.570
1.2.2.2.3	CREW SUPPORT MODULEZEVA	2.613	3.135	0.0	3.135	5.748

		CONTOUTON	NV PER SAT	** OPS CO	** TOTAL		
	MRS # DE	SCRIPTION	NV PER SAI	WC I	OGM	TOTAL OPS	
	1.2.2.3	OPERATIONS	1.091	0.0	0.0	0.0	1.091
	1.2.2.3.1	LEO OPERATIONS CREW	0.749	0.0	0.0	0.0	0.749
	1.2.2.3.2	LEO CREW PROVISIONS	0.342	0.0	0.0	0.0	0.342
	1.2.3	DEM SUPPORT FACILITIES - SATELLITE	1008.386	14.047	0.0	14.047	1022.433
	1.2.3.1	WORK SUPPORT FACILITIES	692.183	7.778	0.0	7.778	699.960
	1.2.3.1.1	AIRLOCK DOCKING MODULE-ADM	40 \$0 56	9.267	0.0	0.267	40.323
	1.2.3.1.2	BASE MGMT MODULE-BMM	283.322	5.666	0.0	5.666	288.989
	1.2.3.1.3	PRESSURIZED STORAGE MODULE-PSM	368 • 805	1.844	0.0	1.844	370.649
	1.2.3.2	CREW SUPPORT FACILITIES	313.476	6.270	0.0	6,270	319.745
* * * * * * *	1.2.3.2.1	AIRLOCK DOCKING MODULE-ADM	13.774	0.275	0.0	0.275	14.049
	1.2.3.2.2	CREW HABITABILITY MODULE-CHM	92.913	1.858	0.0	1.858	94.771
	1.2.3.2.3	CONSUMABLES LOGISTICS MODULE-CLM	63.895	1.278	0.0	1.278	65.173
	1.2.3.2.4	CREW SUPPORT MODULE/EVA	142.894	2.858	0.0	2.858	145.751
	1.2.3.3	OPERATIONS	2.727	0.0	0.0	0.0	2.727
ᄧ	1.2.3.3.1	SATELLITE OPERATIONS CREW	1.872	0.0	0.0	0.0	1.872
21	1.2.3.3.2	SATELLITE CREW PROVISIONS	0.855	0.0	0.0	0.0	0.855
	1.3	TRANSPORTATION	1949.004	119.343	80.869	200.212	2149.216
· ·	1.3.1	SPS-HEAVY LIFT LAUNCH VEHICLE (HLLV)	1256.406	99.642	39.372	139.014	1395.420
	1.3.1.1	SPS-HLLV FLEET	767.020	99.642	24.256	123.898	890.917
	1.3.1.2	SPS-HLLV OPERATIONS	489.387	0.0	15.116	15.116	504.502
	1.3.2	CARGO ORBITAL TRANSFER VEHICLE(COTV)	210.343	1.957	6.371		218.671
	1.3.2.1	COTV VEHICLES	205.681	1.957	6.233	8.190	213.871
		PRIMARY STRUCTURE	0.566	0.005	0.017	0.023	0.589
	1.3.2.1.2	SECONDARY STRUCTURE	142.934	1.364	4.331	5.696	148.630
	1.3.2.1.3	CONCENTRATOR SOLAR BLANKET, SWITCHGEAR AND CONVERTERS CONDUCTORS AND INSULATION	0.914	0.009	0.028	0.036	0.951
	1.3.2.1.4	SOLAR BLANKET	20.077	0.192	0.608	0.800	20.878
	1.3.2.1.5	SWITCHGEAR AND CONVERTERS	0.465	0.001	0.014		0.481
	1.3.2.1.6	CONDUCTORS AND INSULATION SP	0.525	0.002	0.016	0.017	0.542
	1.3.2.1.7	AL S PLAKTIWARD	サルショ トプフ	0.384	1.218	1.602	41.801
	1.3.2.1.8	INFO. MGMT. AND CONTROL 23	0.0	0.0	0.0	0.0	0.0
	1.3.2.2	COTY OPERATIONS	4.662	0.0	0.139	0.139	4.801
	1.3.3	PERSONNEL LAUNCH VEHICLE(PLV)	423.752	12.995	32.927	45.922	469.674
•	1.3.3.1	TOTAL TO THE SECOND CONTRACTOR OF THE SECOND C	and the contract about the same of the same and the same of the sa	12.995	14.047	27.042	215.474
	1.3.3.1.1	STS-PLV ORBITER	100.340	5.797	8.250	14.047	114.387
	1.3.3.1.2	STS-PLV EXTERNAL TANK	41.679	.0 • 0	3.330	3.330	45.010
							•

			ا المعادل في المعادل الم	en e	and the second s	للتحاسية بدراتها حيروا والمريسان	angan ana angan angan angan angan angan angan angan angan ang ang
				** UPS (COST PER SA		** TOTAL
	WBS # DE	SCRIPTION	INV PER SAT	RC I	T M30	OTAL OPS	$\hat{m{t}}_{i}$
	1.3.3.1.3	STS-PLV LIQ. ROCKET BOOSTER	33.991	7.198	2.466	9.664	43.655
1	1.3.3.1.4	STS CARGO CARRIER AND EM	12.423	0.0	0.0	0.0	12.423
100	1.3.3.2	PLV & STS-HLLV OPERATIONS	235.319	0.0	18.880	18.880	254.200
	1.3.3.2.1	PLV OPERATIONS	216.507	0.0	18.880	18.880	235.387
	1.3.3.2.2	STS HLLV CARGO OPERATIONS	18.813	0.0	0.0	0.0	18.813
	1.3.4	PERSONNEL ORBITAL TRANS VEHICLE	2.488	0.736	0.254	0.990	3.478
	1.3.4.1	POTV-FLEET	1 • 8 02	0.736	0.185	0.921	2.723
	1.3.4.2	POTV-OPERATIONS	0.686	0.0	0.069	0.069	0.755
	1.3.5	PERSONNEL MODULE(PM)	1.294	0.199	0.126	0.324	1.618
	1.3.5.1	PM FLEET	0.746	0.199	0.075	0.273	1.019
	1.3.5.2	PM OPERATIONS	0.548	0.0	0.051	0.051	0.599
	1.3.6	INTRAURBITAL TRANSFER VEHICLE(IUTV)	1.471	0.265	0.045	0.310	1.780
	1.3.6.1	10TV FLEET	1.389	0.265	0.042	0.307	1.697
	1.3.6.2	IOTV OPERATIONS	0.081	0.0	0.002	0.002	0.084
	1.3.7	GROUND SUPPORT FACILITIES	53.250	3.550	1.775	5,325	58.575
À		LAUNCH FACILITIES	0.0	0.0	0.0	0.0	0.0
-22	1.3.7.2	RECOVERY FACILITIES	0.0	0.0	0.0	0.0	0.0
~	1.3.7.3	FUEL FACILITIES	0.0	0.0	0.0	0.0	0.0
	1.3.7.4	LOGISTICS SUPPORT	0.0	0.0	0.0	0.0	0.0
	1.3.7.5	OPERATIONS	0.0	0.0	0.0	0.0	0.0
	1.4	GROUND RECEIVING STATION	3590.822	0.275	78.377	78.652	3669.474
	1.4.1	SITE AND FACILITIES	188.934	0.200	0.0	0.200	189.134
	1.4.1.1	LAND AND PREPARATION	99.119	0.0	0.0	0.0	99.119
	1.4.1.1.1	LAND	35.000	0.0	0.0	0.0	35 • 000
	1.4.1.1.2	LAND PREPARATION	64.119	0.0	0.0	0.0	64.119
	1.4.1.2	ROADS AND FENCES	74.138	0.0	0.0	0.0	74.138
	1.4.1.2.1	RAILS AND KUADS	73.710	0.0	0.0	0.0	73.710
	1.4.1.2.2	FENCING	0.428	0.0	0.0	0.0	0.428
	1.4.1.3	UTILITIES	0.200	0.0	0.0	0.0	0.200
	1.4.1.4	BUILDINGS	11.477	0.0	0.0	0.0	11.477
	1.4.1.4.1		1.300	0.0	0.0	0.0	1.300
	1.4.1.4.2	CUNV. STA. & MONITUR/CUNTROL FAC.	10.177	0.0	0.0	0.0	10.177
	1.4.1.5	MAINTENANCE EQPT.	4.000	0.200	0.0	0.200	4.200
	1.4.1.6	LIGHTNING PROTECTION	0.0	0.0	0.0	0.0	0.0
	1.4.1.7	SITE & FACILITIES DUT&E	0.0	0.0	0.0	0.0	0.0

		NATION STREET, A. S. CONTRACTOR OF CONTRACTO		** OPS C	OST PER SAT	F PER YEAR	** TOTAL
WBS #	DESCRIPTION		INV PER SAT	KC I	OT M30	OTAL OPS	•
 1.4.2	RECTENNA SUPPURT STRUCTURE		1827.999	0.075	0.447	0.522	1828.521
1.4.2.1	STEEL PANEL FAB. & INSTALLA	TION	1696.493	0.0	0.0	0.0	1696.493
1.4.2.1.	1 HAT SECTIONS		359.224	0.0	0.0	0.0	359.224
 1.4.2.1.	2 WIDE FLANGES		295 • 170	0.0	0.0	0.0	295.170
1.4.2.1.	3 TUBE BRACES & HARDWARE		431.343	0.0	0.0	0.0	431.343
 1.4.2.1.	4 ASSEMBLY & INSTALLATION		610.756	0.0	0.0	0.0	610.756
 1.4.2.2	TRENCHING & CONCRETE INSTAL	LATION	131.506	0.075	0.447	0.522	132.027
1.4.2.2.	1 FOOTING CONCRETE & RE-BAR		70.820	0.0	0.0	0.0	70.820
 1.4.2.2.	2 MACHINGERY & EQUIPMENT		0.745	0.075	0.447	0.522	1.267
1.4.2.2.	3 CONSTRUCTION OPERATIONS		59.940	0.0	0.0	0.0	59.940
1.4.2.3	SUPPORT STRUCTURE DDT &E		0.0	0.0	0.0	0.0	0.0
1.4.3	POWER COLLECTION		1353.200	0.0	0.0	0.0	1353.200
1.4.3.1	ANTENNA ARRAY ELEMENTS		1127.321	0.0	0.0	0.0	1127.321
1.4.3.2	POWER DISTRIBUTION SYSTEM	20	69 • 659	0.0	0.0	0.0	69 •659
 ω 1.4.3.3	INSTALLATION & CHECKOUT	ORIGINAL OF POOR	156.220	0.0	0.0	0.0	156.220
1.4.3.4	POWER COLLECTION-DOTEE	9	0.0	0.0	0.0	0.0	0.0
1.4.4	CONTROL	ဝူ 🤰	75.000	0.0	0.0	0.0	75.000
1.4.4.1	CONTROL CENTER EQUIPMENT		15.000	0.0	0.0	0.0	15.000
1.4.4.2	CONTROL ELECTRONICS	PAGE QUALI	60.000	0.0	0.0	0.0	60.000
1.4.4.3	CONTROL DDT&E	AG	0.0	0.0	0.0	0.0	0.0
 1.4.5	GRID INTERFACE		145.690	0.0	0.0	0.0	145,690
1.4.5.1	ELECTRICAL EQUIPMENT	₹ ७	145.690	0.0	0.0	0.0	145.690
1.4.5.2	GRID INTERFACE-DUTGE		0.0	0.0	0.0	0.0	0.0
 1.4.6	OPERATIONS		0.0	0.0	77.930	77.930	77,930
1.4.6.1	OPER. & MAINT. PERSONNEL		0.0	0.0	64 -8 00	64.800	64.800
1.4.6.2	MAINT. MATERIAL		0.0	0.0	13.130	13,130	13.130
1.5	MANAGEMENT AND INTEGRATION	and the second second	600.679	18.815	8.561	27.377	628.055
1.0	MASS CONTINGENCY		1263 • 413	56.405	13.927	70.332	1333.745

1.0 SATELLITE POWER SYSTEM (SPS) PROGRAM

The program elements described in this section include all the elements of hardware, software, and activities required for the design, development, production, assembly, transportation, operations and maintenance of the Satellite Power Systems Program. Included are the satellite and ground receiving station systems as well as the necessary support systems such as space construction and assembly equipment, plus transportation.

Cost estimates are presented for DDT&E, Theoretical First Unit (TFU), investment per satellite, replacement capital investment, and operations/maintenance for SPS program elements in the following categories:

- Satellite
- · Space Construction and Support
- Transportation
- Ground Receiving Station
- Management and Integration
- Mass Contingency

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1.1 SATELLITE

Elements of the satellite costed in this section include the hardware and software located in geosynchronous orbit for the collection of solar energy, its conversion to electrical energy, and the transmission of this electrical energy in microwave form to earth.

The satellite concept is of a planar array using GaAlAs photovoltaic cells with a solar reflector (concentrator) to provide a concentration ratio of 2.0 suns. The concept consists of 3 main bays with 10 subsections in each of the main bays and is 16,000 meters long by 3900 meters wide with an end mounted antenna adding another 1750 meters to the length (Figure 1.1-1). The total dry weight of the satellite is 26.416×10⁶ kg (Table 1.1-1). It has a primary structure of composites, GaAlAs solar cells, and a microwave antenna using the klystron power module as a source for the generation of MW energy.

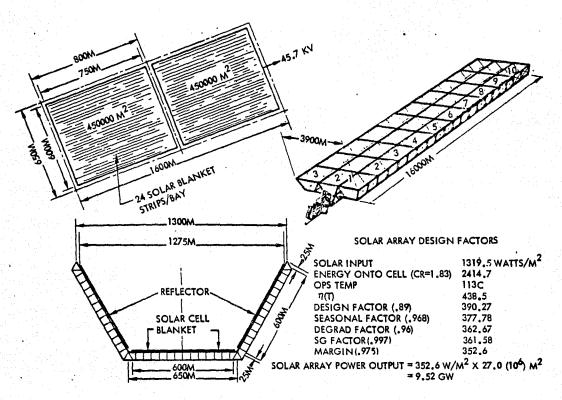


Figure 1.1-1. Solar Array Dimensions

The satellite has been divided into a number of main elements that are included in the following items as described in the SPS-WBS of Appendix A.

- 1.1.1 Energy Conversion
- 1.1.2 Power Transmission
- 1.1.3 Information Management and Control



- 1.1.4 Attitude Control and Stationkeeping
- 1.1.5 Communications
- 1.1.6 Interface
- 1.1.7 Systems Test
- 1.1.8 Ground Support Equipment
- 1.1.9 Precursor Test Article

Table 1.1-1. Solar Photovoltaic Power Conversion

Mass Statement - ~10⁵ kg End-Mounted Antenna

OF POOR

SUBSYSTEM	CO-PLANAR (3 TROUGH)
COLLECTOR ARRAY	
· STRUCTURE AND MECHANISMS	1,260
PRIMARY STRUCTURE	.702
SECONDARY STRUCTURE	.358
MECHANISM	200
ATTITUDE CONTROL	(0.116)
POWER SOURCE	(7.855)
SOLAR PANELS	6.818
SOLAR REFLECTORS	1.037
POWER DISTRIBUTION AND CONTROL	(2.603)
POWER CONDITIONING EQUIPMENT	(.193)
POWER DISTRIBUTION	(2.410)
CONDUCTORS AND INSULATION	(2.367)
SLIP RINGS	.043
INFORMATION MANAGEMENT & CONTROL	(.050)
DATA PROCESSING	.021
INSTRUMENTATION	.029
TOTAL ARRAY, DRY	11.884
ANTENNA SECTION	
STRUCTURE & MECHANISM	(0.977)
PRIMARY STRUCTURE	.120
SECONDARY STRUCTURE	-599
ANTENNA	.067
MECHANISH	.191
THERMAL CONTROL	1.408
KLYSTRON COOLING	.851
INSULATION	.557
milion RADIATOR	
MICROWAVE POWER	(7.012)
KLYSTRONS	4.250
ATT. SEN. ELECTRONICS & PHASE CONTROL	.142
WAVEGUIDES	2.620
POWER DISTRIBUTION & CONTROL	(4.505)
POWER CONDITIONING EQUIPMENT	1.901
POWER DISTRIBUTION	(2.604)
CONDUCTOR & INSULATION	(2.587)
SLIP RING BRUSHES	.017
INFORMATION MANAGEMENT & CONTROL	(.630)
DATA PROCESSING	.380
INSTRUMENTATION	.250
TOTAL ANTENNA SECTION	14.532
TOTAL SPS DRY	26.416

1.1.1 ENERGY CONVERSION

This element includes the components required to collect solar energy, convert the solar energy to electrical energy, condition the electrical energy, and transport it to the interface subsystem (WBS No. 1.1.6).

The satellite structure, solar cells/blankets, concentrators, and power distribution/conditioning subsystems are included in this element plus the necessary maintenance requirements to support operations.

1.1.1.1 STRUCTURE

This element includes all necessary members to support the concentrators, solar blankets, and other energy conversion subsystem hardware. It includes structural beams, beam couplers, cables, tensioning devices, and secondary structures which are required as an interface between the primary structure and the mounting attach points of components, assemblies, and subsystems.

1.1.1.1.1 Primary Structure

The primary SPS structure assemblies are made up, basically, of tribeam girders, tension cables, and joints. The fabrication and assembly of these structures are accomplished on orbit by beam machines and supporting auxiliary equipment. These structural elements are made of a graphite fiber reinforced composite that must individually withstand the forces, torques, and dynamics imposed by the construction process. Once built into an assembly level, the structure must have sufficient strength and stiffness to withstand the forces of the environment (gravity-gradient torques), the attitude control system (forces and frequencies), and the operational equipment (rotary jointsk microwave induced thermal environment).

The SPS requirement for low thermal distortion, under high thermal stress, dictates the need for a material with a very low coefficient of expansion. The most likely candidate, at this time, is a graphite composite material.

The energy conversion structure D&D CER was developed using graphite composite data obtained from NASA's Redstar Data Base. Tooling cost was excluded under the assumption that this cost would be incurred in the development of orbital fabrication equipment. The following data points were used:

- · Space Telescope Shell
- ATS-F Truss
- HEAO Optical Bench
- Shuttle Payload Bay Doors

The primary structure ICI is the cost of raw materials only since the costs associated with fabrication and assembly are charged against orbital assembly and support equipment. The structure ICI cost equation is based on raw composite material stock (prepregnated graphite) cost. These material costs are based on vendor quotes obtained from Hercules, Fiberrite and Union Carbide.

Range of Data

D&D: 30.0 to 2000.0 kg

ICI: Unlimited

1.1.1.1.2 Secondary Structure.

The secondary structure consists of the passive interface attachment between the primary structure and operational subsystems. The structural members are made of aluminum with the ability to articulate, rotate, or otherwise support/allow motion between the primary structure and other subsystem elements.

This element includes all structure, consisting of mounting brackets, clamps and installation structure required as an interface and mounting attach points of components, assemblies, and subsystems. It also includes any structure required between two or more components or assemblies.

Development of the secondary structure CER for DDT&E was based on cost data contained in the MSFC Redstar Data Base. Data from a variety of launch vehicle and unmanned satellite programs were available and the applicable data points are listed below:

- S-IVB Interstage
- S-IC Forward Skirt
- X-IC Intertank
- Solar Telescope Housing Assembly (ASM)
- Common Mount Assembly ASM)
- Telescope Gimbal Assembly (ASM)
- Common Mount Actuators (ASM)
- Telescope Gimbal Actuators (ASM)
- · Array Platform Elevation Pointing Actuator (ASM)
- UV Gimbal Mount Actuators (ASM)
- UV Instrument Mount Assembly (ASM)
- Solar Array and Boom Structure (ATS-F)
- Squib Interface Unit (ATS-F)
- Interstage (Centaur)
- Nose Shroud (Centaur)
- Fixed Airlock Shroud (Skylab)
- Payload Shroud (Skylab)
- Pallet Segment (Spacelab)
- OSO-1
- ATS-F
- · S-II

The ICI production cost CER was based upon an Engineering Cost estimate.

Range of Data:

DDT&E: 6.0 to 15,000.0 kg ICI: 6.0 to 15,000.0 kg

Input parameters T&M are in kilograms of mass.

1.1.1.1.3 Cost Estimates

Table 1.1.1.1 and 1.1.1.2 cover cost estimates associated with the primary and secondary structures.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.1.1 PRIMARY STRUCTURE

		entropa y matematica (n. 1916). Maria								
		INPUT P	ARAMETERS			IN	PUT COEF	FICIENT	S	
	7.0	2000.000	TF=	1.000000		CDCER=		0.0230	00	
		1700.0000	=M3O	0.0		CDEXP=	- 1	0.8000	~~~~	
	CF=	1.000000	Z1=	1.000000		CICER=		0.0000		
	PH I=	1.000000	72=	60.000000		CIEXP=		1.00000		
	R=	0.002000	Z3=	60.000000					<u> </u>	
	DF=	0.020000	Z 4 =	60.000000	25 =		0.0			
	CALCULATE	D VALUES	KG	SUM TO	1.1.1.1				\$,MILLIONS	
	CD=CDCER X (T	X DF)XX(CDEXP) X CF					4 <u>3444, 1</u> 1 - 11 - 11 - 11 - 11 - 11 - 11 - 11	47.821	
	CLRM=CICER X (M)XX(CIEXP) X	CF X TF						0.585	
	#RM =T / M		· · · · · · · · · · · · · · · · · · ·					60.00	00	· · · · · · · · · · · · · · · · · · ·
<u>.</u>	E = 1.0 + LOG	(PHI) / LOG(2	.0)					1.00	00	· · · · · · · · · · · · · · · · · · ·
	CTFU=(CLRM / E)X((#RM X Z1+	.5)XX(E) -0.	.5XX(E))					35.100	
	CTB = ((CLRM/E)	X((#RM X Z	3 + 0.5)XX([E) -0.5XX(E))) / Z3			35.100	
	CIPS=CTB*Z4/Z2							***************************************	35.100	
· · · ·	CRCI =CTB	X R							0.070	
	CCEM = DEM	OR CTB*Z5/Z2	/ENYR						0.0	
	COMMENTS		na katalangan ang ang ang ang ang ang ang ang an	er en	dentana aria pera mada amang arang dipanganan dan pian d					**************************************

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.2 SECONDARY STRUCTURE

TAIDIAT	ARAMETERS	TAIDIIT	COEFFICIENTS			
	ARAMETERS	INFO: COLITICIANS				
T= 358000.000	TF= 0.00730	OO CDCER=	0.156000			
M= 5.000000	0.0 = M30	CDEXP=	0.511000			
CF= 1.000000	Z1= 1.00000	O CICER=	0.101000			
PH I= 0.980000	Z 2= 60.00000	OO CIEXP=	0.355000			
R= 0.002000	Z3= 60.00000					
DF= 0.050000	Z4= 60.00000	00 Z5= 0.				
CALCULATED VALUES	KG SUM TO	1.1.1.1	\$,MILLIONS			
CD=CDCER X (T X DF)XX(CDEXP) X CF	gergygen akkanga, angang panggang sa angang panggang panggang panggang panggang panggang panggang panggang pan	23.245			
CLRM=CICER X (M)XX(CIEXP) >	CF X TF		0.001			
#RM =T / M			71600.000			
E =1.0 + LOG(PHI) / LOG(2	2.01		0.971			
CTFU=(CLRM / E)X((#RM X Z1+	.5)XX(E) -0.5XX(E))		69.508			
CTB =((CLRM/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E)) / 23	61.689			
CIPS=CTB*Z4/Z2		nder spier ist ige ness desset skrive, maardefelingen maaren valub verschieren de verschiere gebruik de verschieren de verschi	61.689			
CRCI =CTB X R			0.123			
COEM = OEM OR CTB*Z5/Z2	P/ENYR		0.0			
COMMENTS	and the second section of the second section of the second section of the second section of the second section section of the second section of the second section section of the second section secti					



1.1.1.2 CONCENTRATORS

This element concentrates the solar energy onto the solar blanket to increase the energy density on the conversion device. It includes the reflective material and any integral attach points required for mounting. Excluded are tools and support equipment required for deployment and tensioning.

Concentrator membranes are used to reflect the sun onto the solar cell surfaces and obtain a nominal concentration ratio of 2. The concentrator is made of (0.5-mil) aluminized Kapton. The membrane has a mass of 0.018 kg/m² and is mounted on the structure using attachments and tensioning devices. Excluded are tools and support equipment required for deployment.

The DDT&E CER (CD) is based on thin sheet aluminum vendor data. The ICI CER for concentrators is based on Rockwell data for Type H Kapton material with an aluminized coating. As concentrator thickness decreases, cost per unit area decreases due to the diminished material requirements. However, at around 25 microns (1 mil), the cost reductions are cancelled by the increased difficulty of processing thin materials and the overall cost per unit area begins to rise. Rockwell data from Dupont indicates that the current cost of 0.5 mil concentrator for the SPS would be about \$4.73 per square meter. At increased demand and increased yields, cost could potentially reach \$1.61 per square meter. However, the most likely value, and the value on which the concentrator ICI CER is based, was quoted at \$2.58 per square meter. For the purposes of the CER this was rounded to \$3.00 per square meter to include sensors and mounting attachments and scaled at a slope of 0.95 to reflect anticipated large array economies.

Range of Data

DDT&E: 100 M²- 100,000 M²

ICI: Unlimited

Input parameters T&M are in square meters, see Table 1.1.1.2.

		ROCKWELL	SPS CR-2	REFERENCE	CONFIGURATION
TABL	.E 1.1.	1.2 CON	CENTRATOR	S	
	English Committee				

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anger de ploker be

		·				
	INPUT PARAMI	TERS		INPUT COEFFI	CIENTS	r (grand) pipti kirikin ngipe ngadan r nga p a dipapa n pipunangan ngag sak
	T= 54000000.0 TI	1.000000	CDCE	≀= 0	•0	
	M= 450000.000 0&1		CDEXI		•0	
	CF= 1.000000 Z	1.000000	CICER	!= 0	.000003	
	PHI= 0.980000 Z			P= <u>0</u>	•950000	
	R= 0.002000 Z					
	DF= 1.000000 Z	= 60.000000	Z5 =	0.0		
	CALCULATED VALUES SO	M SUM TO	1.1.1		\$,MILLIONS	
	CD=CDCER X (T X DF)XX(CDEXP) X	F		d ka ni Nagajada ka jer sa podjedi sa slovanskepini Viljoji kaliga gene dje o oslok	0.0	one conque con in the selection of
	CLRM=CICER X (M)XX(CIEXP) X CF	(TF			0.704	
	#RM = T / M				120.000	
	E = 1.0 + LOG(PHI) / LOG(2.0)				0.971	المستحيد فللمستطوع ويراجه فيكان المامة والإنسان المستجاب
В-34	CTFU=(CLRM / E)X((#RM X Z1+.5)X)	((E) -0.5XX(E))			75.637	
	CTB = ((CLRM/E)X((#RM X Z3 + C	.5)XX(E) -0.5XX(E))	1./	Z3	67.184	
	CIPS=CTB*Z4/Z2	and the second of the second o		o en come e em de o en	67.183	Transfer for a partie of the contract of the second of the contract of the con
· · · · · · · · · · · · · · · · · · ·	CRCI =CTB X R				0.134	
	° COEM = OEM OR CTB*Z5/Z2/ENYF				0.0	
	COMMENTS	and the same of th	to provide the species of all the secretary the of a first on the secretary of		era erreta an 'a personale tende sep cara care an ancienta antica de partir partir de la care	***************************************
						*

1.1.1.3 SOLAR BLANKET

This element converts solar energy to electrical energy and provides power to the power distribution and conditioning buses. It includes the photovoltaic conversion cells, cover-plates, substrate, electrical interconnects, and any integral attach points required for mounting. Excluded are tools and support equipment required for deployment and tensioning.

Gallium aluminum arsenide (GaAlAs) cells have been selected. The cell consists of GaAs junction with a GaAlAs window, substrate, adhesive, current collectors, and an anti-reflective coating. The solar blanket consists of a Kapton membrane upon which the cells are fastened with a thermo-setting FEP adhesive. Also included in the blanket are the interconnects, thermal coating, attachments/tensioning devices, and sensors.

Historical cost data on solar arrays from previous satellite programs were readily available from the Redstar Data Base and were used to develop the CD CER. However, due to the rapidly changing technology, historical data is not applicable for use in estimating the SPS solar blanket production cost. The Department of Energy (DOE) has initiated the U.S. Photovoltaic Conversion Program. Two main objectives of this program are to develop by 1990 the technological and industrial capability to produce silicon solar arrays at a price of less than \$500 per peak KWe and to establish by 2000 the viability of even lower-cost (\$100 to \$300 per KWe) and/or more efficient alternatives utilizing novel materials and devices. Since it is generally believed throughout the photovoltaic industry that low cost solar arrays are achievable and dependent on the demand for high production rates and since some progress toward meeting the DOE goal has already been made, it was decided to base the SPS solar array cost estimates on projected costs rather than historical costs.

The CD CER was based on solar array historical cost data from the following programs.

- Skylab (OWS)
- Skylab (ATM)
- FRUSA
- SEPS (Est.)

The cost of array structure and mechanisms was not included so that the data would be compatible with the SPS concept of on-orbit structure fabrication and assembly. Although there is a large difference in size between the above arrays and the SPS array, the SPS array will consist of a large number of smaller units. The development fraction (DF) was utilized to normalize the CD cost to reflect cost of only that portion of the total solar array area required to develop the power system.

The initial capital investment CER (CI) cost estimate for material and production processing was based upon information contained in the Arthur D. Little report of March 1978 as prepared under Contract NAS9-15294 with NASA/JSC. The materials cost of $\$33/\text{M}^2$ and a fabrication cost of $\$34/\text{M}^2$ total $\$67/\text{M}^2$ for a gallium arsenide solar cell array. This assessment is consistent with work completed under Rockwell company sponsored activity based on 1977 prices and assuming 1990 technology.

Range of Data:

DDT&E: 10-300 square meters

ICI: Unlimited

Cost estimates are shown in Table 1.1.1.3.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.3 SOLAR BLANKETS

INPUT PARAME	TERS INPU	T COEFFICIENTS
T= 27000000.0 TF		0.0
M= 18750.0000 08M CF= 1.000000 Z1 PHI= 0.990000 Z2	= 1.000000 CICER=	0.0 0.000067 1.000000
R= 0.002000 Z3 DF= 1.000000 Z4		• 0
CALCULATED VALUES SQ		\$,MILLIONS
CD=CDCER X (T X DF)XX(CDEXP) X C	F	0.0
CLRM=CICER X (M)XX(CIEXP) X CF X	TF	1.256
#RM = T / M		1440.000
E =1.0 + LOG(PHI) / LOG(2.0)		0.986
CTFU=(CLRM / E)X((#RM X Z1+.5)XX	(E) -0.5XX(E))	1651.832
CTB = ((CLRM/E)X((#RM X Z3 + 0	.5)XX(E) -0.5XX(E))) / Z3	1556.693
CIPS=CTB*Z4/Z2		1556.692
CRCI =CTB X R		3.113
CC&M = O&M OR CTB*Z5/Z2/ENYR		0.0
COMMENTS		

1.1.1.4 POWER DISTRIBUTION AND CONDITIONING (PD&C)

This element includes the various power feeders, switching and conditioning equipments necessary to deliver power at the required voltage and power levels throughout the satellite. An energy storage system is included, as a power source, to supply minimum power to the various subsystems during eclipse periods. Data buses are not a part of this element as they are included in the information management and control subsystem (WBS No. 1.1.3).

The PD&C system receives power from the solar photovoltaic power generation system and provides for the power conditioning and switching required to deliver the power, through its distribution network, to the satellite power transmission system. Electrical power is transferred from the solar array distribution network through a rotary joint, utilizing slip rings and brushes, to the microwave antenna distribution and conditioning system for the delivery of power at the required levels. The life expectancy of the PD&C is 30 years with the exception of the energy storage system (batteries), which is projected to have a life expectancy of 15 years.

1.1.1.4.1 Switches and Converters

Switches will be used to perform various functions and will be monitored and controlled through the IMCS. Switchgears will:

- · Isolate solar array blankets for maintenance work
- Provide voltage regulation of solar array output by selective switching of isolation switchgears
- Control voltage and currents through the IMCS system for short circuit protection
- Prevention of large line transients
- Systematic start-up and shut-down of array during eclipse periods
- · Control various loads

The primary switches will be of the Penning cross-field tube design. Functions controlled by these switches will be monitored by the IMCS to determine their status and establish the opening or closing position as required. Basically, the switches are held in a closed state during the operational mode. During start-up and shut-down operations, switches will be monitored by the IMCS, and when certain voltage levels are reached, a command signal will open or close switches as needed.

The power converter and conditioners convert the existing bus voltages to the subsystem voltage required for the various subsystem loads. The output tolerances will be based on the using subsystem interface requirements. The power converters are utilized in the GEO mode of operation.

1.1.1.4.2 Conductors and Insulation.

Main feeders are generally sized to minimize the combined mass of itself and the solar array mass, considering power requirements, efficiency, and the variation in resistivity with operating temperature. The power distribution system utilizes flat aluminum (6101/T6) feeders where feasible, and round conductors for those subsystems where flat conductors are not feasible.

The CD CER was based on historical cost data obtained from the Redstar Data Base on the following satellite programs.

- DSCS-II
- ATS-A
- ATS-F
- ATS-E
- OSO-I
- HEAO
- ATS-B

The ICI CER was based on preprocessed aluminum material cost data and the use of 6101/T6 aluminum. Differential aluminum inflation between current prices and expected mid 1986 prices was included. Cost data was obtained from the following manufacturers:

- · Reynolds Metals
- Alcoa Aluminum
- · Amchem Products, Inc.
- · The Yoder Company

Range of Data:

DDT&E: 20 to 150 kilograms

ICI: Unlimited

1.1.1.4.3 Slip Rings

The slip ring portion of the rotary joint is included in the PD&C of the Energy Conversion segment. The slip rings consist of an aluminum core with coin silver cladding on each slip ring. The core cross section is 33.7 cm². The slip ring diameter is .3 km with a length of .94 km. Each slip ring weighs 10,715 kg with a total weight of 42,860 kg for the required 4 slip rings.

The cost data for the slip rings cost data are based upon large ground commercial and military slip rings. Since all but one of the base data slip rings were designed for ground application, it was decided that these data should not be used as a basis for estimating DDT&E costs. It was determined that the data should be used only as a basis for estimating ICI production costs and then only after applying complexity and specification uprating factors. The following factors were applied:

Complexity Factor
$$\times$$
 3
Specification Uprating Factor \times 3
Total \times 9

The ICI production cost CER was based on data provided by the following manufacturers.

Manufacturer Application
Poly-Scientific High energy

Poly-Scientific Radar

Electro-Tec Navy destroyer propeller system

Electro-Tec Satellite solar array I.E.C. Navy shipboard hoist

Due to the relatively low production rate of 1 to 5 units per year, the tooling factor is assumed to be 1.0.

The DDT&E cost was estimated with a CER developed for secondary structure which consisted of space qualified hardware of approximately the same complexity. See the discussion of the secondary structure CER.

Range of Data.

1.1.1.4.4 Batteries

Batteries will be utilized during ecliptic periods to provide minimum energy required by the energy conversion subsystems. The batteries will be of a sodium chloride design, having a density of at least 200 watt hours/kg.

The DDT&E and the ICI CER's were developed using battery data from the manned/unmanned spacecraft list below:

• APOLLO Lunar Module

• ATS-F

• APOLLO Lunar Rover

HAWKEYE

· ATS-E

• OSO-I

Range of Data:

DDT&E: 1.0 to 180.0 kg ICI: 1.0 to 180.0 kg

1.1.1.4.5 Battery PD&C

This element provides the mechanism for the charging of the satellite batteries and the distribution and regulation of power to and from the batteries. Included are the battery chargers, power regulators, power conditioning and power conditioning equipment which directly interface with the battery subsystem.

The DDT&E and the ICI CER's were developed using data from the manned and unmanned spacecraft below:

• APOLLO Lunar Module

• GEMINI.

• APOLLO Lunar Rover

HAWKEYE

Satellite Systems Division Space Systems Group



• ATS-E

• OSO-I

• ATS-F

Range of Data:

DDT&E: 2.0 to 68.0 kg ICI: 2.0 to 68.0 kg

1.1.1.4.6 PD&C Cost Estimates

Cost calculations developed from the CER's discussed in the preceding paragraphs are presented in the following tables:

<u>Table</u>	Description
1.1.1.4.1	Switch Gear and Converters
1.1.1.4.2	Conductors and Insulation
1.1.1.4.3	Slip Rings
1.1.1.4.4	Batteries
1.1.1.4.5	Battery PD&C

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.4.1 SWITCH GEAR & CONVERTERS

		INPUT F	ARAMETERS			IN	PUT CO	EFFI CI ENTS	
	T=	187000.000	TF=	1.000000		CDCER=		0.158000	
	M=	3117.00000	=M3O	0.0		CDEXP=		0.297000	
	CF=	1.500000	Z 1 =	1.000000		CICER=		0.000400	
	PHI=	0.950000	Z 2=	60.000000		CIEXP=		1.00000	
	R=	0.0	Z 3 =	60.000000					
	DF=	0.050000	Z 4=	60.000000	Z5 =		0.0		
	CAL CUL	ATED VALUES	KG	SUM TO 1	1.1.1.4			\$, MILL IONS	
-	CD=CDCER X	(T X DF)XX(CDEXP) X CF				-1	3.582	
	CLRM=CICER	X (M)XX(CIEXP)	CF X TF					1.870	
	#RM =T / M							59.994	
R-43	E = 1.0 +	LOG(PHI) / LOG(2	.0)					0.926	<u> </u>
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				89.123	
	CTB = ((CLR)	1/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3		66.093	
	CIPS=CTB*Z4	4/Z2		ende an e menera sabaga elektrister has has men tersahasangan bermangan se an merupahan		a garan managan atau atau atau atau atau atau atau at	er en straan te de asternaanse en strajen	66.093	
	CRCI =	CTB X R						0.0	
	CC&M =	OEM OR CTB*Z5/Z2	/ENYR					0.0	
	COMMENTS								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.4.2 CONDUCTORS & INSULATION

		<u> Stanton de la companya de la comp</u>					
		INPUT	PARAMETERS			INPUT CO	EFFICIENTS
	Τ=:	2367000.00	TF=	1.000000		CDCER=	0.158000
· · · · · · · · · · · · · · · · · · ·	M=	19725.0000	=M3O	0.0		CDEXP=	0.297000
	CF=	14000000	Z1=	1.000000		CICER=	0.000004
	PH I=	1.000000	Z 2 =	60.000000		CIEXP=	1.00000
	R=	0.0	Z3=	60.000000			
	DF=	0.100000	Z 4=	60.000000	Z5 =	0.0	
	CALCU	JLATED VALUES	KG	SUM TO	1.1.1.4		\$, MILLIONS
	CD=CDCER >	((T X DF)XX(CDEX	P) X CF				6.234
	CLRM=CICE	R X (M)XX(CIEXP)	X CF X TF				0.079
ы	#RM =T / N	1	 				120.000
B-43	E =1.0	LOG(PHI) / LOG(2.0)				1.000
	CTFU= (CLRM	4 / E)X((#RM X Z1	+.5)XX(E) -	-0.5XX(E))			9.468
	CTB = ((CLF	RM/E)X((#RM X	Z3 + 0.5)X)	((E) -0.5XX(E))		1 / 23	9.468
	CIPS=CTB*	24/22					9.468
	CRCI	=CTB X R					0.6
		= O&M OR CTB*Z5/Z	2/ENYR				0.0
	COMMENTS						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.4.3 SLIP RINGS

		INPUT P	ARAMETERS	**************************************		INPU	T COEFFICIENTS	
	Tal. 80	43000.0000	TF=	1.000000		CDC ER =	0.156000	
	M=	10750.0000	=M30	0.0		CDEXP=	0.511000	
	CF=	1.500000	Z1=	1.000000		CICER=	0.000764	
	PH I=	0.900000	Z 2=	60.000000		CIEXP=	0.950000	1 (1) (1) (1) (1) (1) (1) (1) (1
	R=	0.010000	Z3=	60.000000				
	DF=	0.020000	Z4=	60.000000	Z5 =	(a) (b) (b) (b) (c) (c)		
	CALCUL	ATED VALUES	KG	SUM TO 1	.1.1.4		\$,MILLIONS	
· ·	CD=CDCER X	(T X DF)XX(CDEXP) X CF				7.392	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				7.745	en enemen net en en elementario en elementario en elementario en elementario en elementario en elementario en e
В -	#RM =T / M						4.000	
-44	E =1.0 +	LOG(PHI) / LOG(2	.0)				0.848	
:	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0.	5XX(E))			27.626	•
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E	-0.5XX(E)) / Z3	15.825	
	CIPS=CTB*Z4	/22					15.825	
	CRCI =	CTB X R					0.158	
	COEM =	O&M OR CT8*Z5/Z2	/ENYR				0.0	
	COMMENTS		a ratio a resistante con compaño de compaño					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.4.4 BATTERIES

	INPUT	PARAMETERS		INPUT C	OEFFICIENTS	
	T= 4000.00000	TF=	0.075600	CDCER=	0.037000	
	M= 50.00000	=M30 (0.010000	CDEXP=	0.734000	
	CF= 1.000000		1.000000	CICER=	0.028000	
	PHI= 0.950000		60.000000	CIEXP=	0.241000	
	R= 0.033333		120.000000			}
	DF= 0.20000		60.000000	Z5= 0.0		
		- · · · · · · · · · · · · · · · · · · ·				
	CALCULATED VALUES	KG	SUM TO 1.1	.1.4	\$, MILL IONS	
	CD=CDCER X (T X DF)XX(CDE	XP) X CF			5.001	
	CLRM=CICER X (M)XX(CIEXP)	X CF X TF			0.005	de an una cidada (de seguina da político persona estidor tale
''	#RM =T / M	- 10 - 10 - 10 - 10 - 10 - 10 - 10 - 10			80.000	
B-45	E =1.0 + LOG(PH() / LOG	(2.0)			0.926	
	CTFU=(CLRM / E)X((#RM X Z	1+.5)XX(E) -0).5XX(E))		0.338	
	CTB = ((CLRM/E)X((#RM X	Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	0.238	
	CIPS=CTB*Z4/Z2				0.238	
	CRCI =CTB X R				0.008	
	CC&M = O&M OR CTB*Z5/	Z2/ENYR			0.010	
	COMMENTS	and a second to the second to				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.1.1.4.5 BATTERY PD&C

:		INPUT	PARAMETERS			IN	PUT COE	FFICIENTS	
		2000.00000	TF=	0.043000		CDCER =		0.053000	
	M=	250.000000	=M30	0.0		CDEXP=		0.890000	
	CF=	1.000000	Z 1 =	1.000000		CICER=		0.012000	
	PHI=	0.950000	Z 2=	60.000000		CIEXP=		0.859000	
	R=	0.010000	Z3=	60.000000					
	DF=	0.500000	Z 4=	60.000000	25 =		0.0		
									·
	CAL CUL A	TED VALUES	KG	SUM TO	1.1.1.4			\$, MILLIONS	
	CD=CDCER X (T X DF)XX(CDEX	(P) X CF		may kanaganggamanggamangga a mma. I sawiyan			24.790	
•	CLRM=CICER X	(M)XX(CIEXP)	X CF X TF					0.059	
	#RM = T / M							8.000	
-46	E = 1.0 + L	OG(PHI) / LOG(2.0)					0.926	
	CTFU=(CLRM /	E)X((#RM X Z1	+.5)XX(E) -	0.5XX(E))				0.430	
	CTB = ((CLRM/	E)X((#RM X	Z3 + 0.5)XX	(E) -0.5XX(E))	•) / Z3		0.324	
	CIPS=CTB*Z4/	7.2			raylanan yangab a maraya di ilinanan garabban nagarabi di siya sabibi ini	e official and an experience of the second s		0.324	
	CRCI = C	TB X R						0.003	, , , , , , , , , , , , , , , , , , ,
		&M OR CTB*Z5/Z	2/ENYR					0.0	
	COMMENTS								

1.1.1.5 THERMAL CONTROL

This element includes any component used to modify the temperature of the energy conversion subsystem components. It includes cold plates, heat transfer and radiator devices as well as insulation, thermal control coatings and finishes. Excluded are paints or finishes applied to components during their manufacturing sequence.

1.1.1.6 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and in situ repair equipment.

The maintenance requirements of this element are related to the energy conversion section of the satellite covering the main structure, concentrators, solar blankets, and power distribution/conditioning. Some of the items of maintenance equipment will be commonly used on the satellite power transmission and interface segments. In these cases, the costs have been apportioned to the related WBS element. Maintenance requirements are listed in Table 1.1.1.6 and costs are presented in Tables 1.1.1.6.1, 1.1.1.6.2 and 1.1.1.6.3.

Table 1.1.1.6 Maintenance Requirements

WBS NO.	MAINTENANCE ITEM DESCRIPTION	1.1.1.6 ENERGY CONVERSION
1.1.1.6.1	"Free-Flyers" or Barge for Cargo and Personnel (Common Use Item)	0.8 Vehicle Utilization
1.1.1.6.2	Manned Manipulator Module	l Vehicle
1.1.1.6.3	Tracks and Access Ways	84,000 kg

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.6.1 MAINTENANCE - FREE FLYERS

		INPUT PA	RAMETERS		ya m <u>angandin menyangan</u> akan berbagawan	INPUT	COEFFICIENTS	
	T= 5000.	00000	TF=	1.000000		CDCER=	0.0	
	M= 5000.	00000	=M30	0.0		CDEXP=	0.0	
(F= 1.	250000	Z1 =	0.800000		CICER=	0.005798	
Pł	I = 0.	950000	Z 2 =	60.000000	<u> </u>	CIEXP=	1.000000	
		020000	Z3=	48.000000				
)F=	000000	Z 4=	48.000000	25=	0.0		
	CALCULATED VAL	UES	KG	SUM TO 1	.1.1.6		\$, MILL IONS	
CD=CI	CER X (T X DF)	XX(CDEXP)	X CF			· · · · · · · · · · · · · · · · · · ·	0.0	
CLRM=	CICER X (M)XX	(CIEXP) X	CF X TF				36.238	
ு #RM =	T / M						1.000	
4	1.0 + LOG(PHI)	/ LOG(2.	0)				0.926	
CT FU=	(CLRM / E)X((#	RM X Z1+.	5)XX(E) -0.5	5XX(E))			29.299	
CTB =	((CLRM/E)X((#F	RM X Z3	+ 0.5)XX(E)	-0.5XX(E))) / 23	29.240	
CIPS=	CTB*Z4/Z2						23.392	
	RCI = CTB X F						0.585	
	.O&M = O&M OR (CT B* Z5/Z2/	ENYR				0.0	
COMMI	NT S							

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.6.2 MANNED MANIPULATOR

		INPUT PA	ARAMETERS	ana a nama di anada ina dalah salah sa		IN	PUT COEFF	ICIENTS	
	1	3000.00000	TF=	1.000000		CDCER=		0.0	
	M=	3000.00000	=M30	0.0		CDEXP=		0.0	
	CF=	1.100000	Z1=	1.000000		CICER=		0.005798	
	PHI=	0.950000	Z 2=	60.000000		CIEXP=		1.00000	
-	R=	0.020000	Z3=	60.000000					
	DF=	1.000000	Z4=	60.000000	25 =		0.0		
	CALCULAT	ED VALUES	KG	SUM TO	1.1.1.6			\$, MILLIONS	
	CD=CDCER X (T	X DF)XX(CDEXP)	X CF				n National Contra	0.0	
Trape capital for	CLRM=CICER X	(M)XX(CIEXP) X	CF X TF					19.133	
ᆑ	#RM =T / M							1.000	
B-50	E =1.0 + LO	G(PHI) / LOG(2.	.0)					0.926	• • • • • • • • • • • • • • • • • • • •
	CTFU=(CLRM /	E)X((#RM X Z1+.	5)XX(E) -0	.5XX(E))				19.203	
:	CTB =((CLRM/E)X((#RM X Z3	+ 0.5)XX(E) -0.5XX(E))		1 / 23		15.198	
	CIPS=CTB*Z4/Z	2					ago, na quanta area n e agoga d e raspango que e e spango de	15.198	
	CRCI =CT	B X R						0.304	
		M OR CTB*Z5/Z2/	ENYR					0.0	
- okaun oo yaakan ka	COMMENTS	rak kalanturus () — direkturus kondinaksisi () () — diddinaksisi direkturus () — direkt						AND THE RESERVE OF THE PROPERTY OF THE PROPERT	er eranada, amerikan, er aria, ana apada, e

()

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.1.6.3 TRACKS & ACCESS WAYS

INPUT PARAMETERS					INPUT COEFFICIENTS				
Τ=	84000.0000	TF=	1.000000		CDCER=	0.0			
			0.0		CDEXP=	0.0			
					CIEXP=	1.000000			
		= = .		75	•				
UF-	0.200000	24-	80.000000	75 -	•				
CALCUL	ATED VALUES	KG	SUM TO 1.	1.1.6		\$, MILLIONS			
CD=CDCER X	(T X DF)XX(CDEXP) X CF				0.0			
CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				0.420			
#RM = T / M						1.000			
E = 1.0 +	LOG(PHI) / LOG(2	.0)				1.000			
CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			0.420			
CTB = ((CLRM	/E)X((#RM X Z	3 + 0.51XX	E) -0.5XX(E))) / Z3	0.420			
CIPS=CTB*Z4	/22					0.420			
CRCI =	CTB X R					0.001			
CO&M =	O&M OR CTB*Z5/Z2	/ENYR				0.0			
COMMENTS		and the same of th			distance of the experience of experience experience.				
	M= CF= PHI= R= DF= CALCUL CD=CDCER X CLRM=CICER #RM = T / M E = 1.0 + CTFU=(CLRM CTFU=(CLRM CTPS=CTB*Z4 CRCI = CO&M =	T= 84000.0000 M= 84000.0000 CF= 1.000000 PHI= 1.000000 R= 0.002000 DF= 0.200000 CALCULATED VALUES CD=CDCER X (T X DF)XX(CDEXP CLRM=CICER X (M)XX(CIEXP) X #RM = T / M E = 1.0 + LOG(PHI) / LOG(2 CTFU=(CLRM / E)X((#RM X Z1+ CTB = ((CLRM/E)X((#RM X Z1+ CTB = CTB X R CO&M = O&M OR CTB*Z5/Z2	T= 84000.0000 TF= M= 84000.0000	T= 84000.0000 TF= 1.000000 M= 84000.0000	T= 84000.0000 TF= 1.000000 M= 84000.0000 D&M= 0.0 CF= 1.000000 Z&= 1.000000 R= 0.002000 Z3= 60.000000 DF= 0.200000 Z4= 60.000000 Z5= CALCULATED VALUES KG SUM TO 1.1.1.6 CD=CDCER X (T X DF)XX(CDEXP) X CF CLRM=CICER X (M)XX(CIEXP) X CF X TF #RM =T / M E =1.0 + LOG(PHI) / LOG(2.0) CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E)) CIPS=CTB*Z4/Z2 CRCI =CTB X R CO&M = O&M OR CTB*Z5/Z2/ENYR	T= 84000.0000 TF= 1.000000 CDCER= M= 84000.0000 O&M= 0.0 CDEXP= CF= 1.000000 ZA= 1.000000 CICER= PHI= 1.000000 Z2= 60.000000 CIEXP= R= 0.002000 Z3= 60.000000 Z5= CALCULATED VALUES KG SUM TO 1.1.1.6 CD=CDCER X (T X DF)XX(CDEXP) X CF CLRM=CICER X (M)XX(CIEXP) X CF X TF #RM =T / M E =1.0 + LOG(PHI) / LOG(2.0) CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 CIPS=CTB*Z4/Z2 CRCI =CTB X R CO&M = O&M OR CTB*Z5/Z2/ENYR	T= 84000.0000 TF= 1.000000 CDCER= 0.0 M= 84000.0000 D8M= 0.0 CDEXP= 0.0 CF= 1.000000 Z1= 1.000000 CICER= 0.000005 PHI= 1.000000 Z2= 60.000000 CIEXP= 1.000000 B= 0.002000 Z3= 60.000000 DF= 0.200000 Z4= 60.000000 CALCULATED VALUES KG SUM TO 1.1.1.6 \$,MILLIONS CD=CDCER X (T X DF)XX(CDEXP) X CF 0.0 CLRM=CICER X (M)XX(CIEXP) X CF X TF 0.420 #RM = T / M 1.000 E = 1.0 + LOG(PHI) / LOG(2.0) 1.000 CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) 1 / Z3 0.420 CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E)) 1 / Z3 0.420 CTB = CTB X R 0.001		

1.1.2 MW POWER TRANSMISSION

This element receives dc electrical power from the interface subsystem, conditions the power, converts it to microwave energy and radiates the energy to the ground receiving station. Included are power distribution from the interface subsystem, dc to RF conversion devices, control and monitoring equipment, and antenna radiating elements.

Costs in this section include those of the antenna structure and sub-arrays with their klystrons; the power distribution and conditioning system; thermal control; phase reference system; and maintenance requirements. The MW antenna system is illustrated in Figure 1.1-2 and illustrates the basic configuration, including overall dimensions of the selected antenna structure concept.

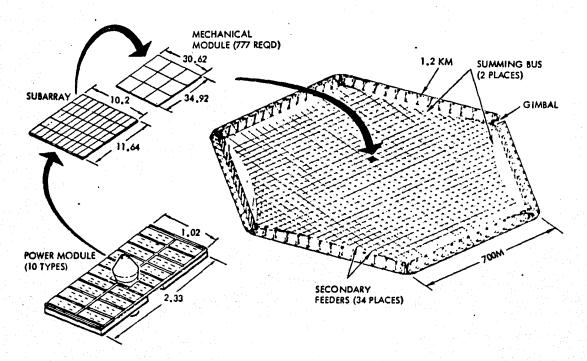


Figure 1.1-2. Microwave Transmission System
- Satellite Antenna

The smallest antenna building block is the power module, which varies in size from the one illustrated (which is used at the center portion of the antenna) to 3.40 by 5.82 meters at the periphery of the antenna. Ten different power module sizes are used to comprise the antenna element. Each power module has a klystron located in its center. The power modules are arranged into subarrays measuring 10.2 by 11.64 meters. Each subarray has its own phase control electronics. Nine subarrays are connected to form a mechanical module 30.82 by 34.92 meters.

1.1.2.1 STRUCTURE

This element includes all members necessary to support the transmitter subarrays and other power transmission subsystem hardware. It includes structural beams, beam couplers, cables, tensioning devices, and secondary structures.

1.1.2.1.1 Primary Structure

This element includes the basic supporting framework of the microwave antenna power transmission system up to the interface connection. The antenna primary structure has three main components — a tension web made from composite wires or tapes; a catenary cable that transfers the web tension to the verticies; and the octogonal compression frame. The antenna frame provides a structural support but does not include the wave guides or radio frequency assemblies associated with the microwave subsystem.

This element is limited to primary load carrying structure and does not include other secondary structure such as equipment mounts, platforms, and space equipment supports.

The SPS requirement for low thermal distortion, under high thermal stress, dictates the need for a material with a very low coefficient of expansion. The most likely candidate, at this time, is a graphite composite material.

The antenna structure D&D CER was developed using graphite composite data obtained from NASA's Redstar Data Base. Tooling cost was excluded under the assumption that this cost would be incurred in the development of orbital fabrication equipment. The following data points were used:

- Space Telescope Shell
- ATS-F Truss
- HEAO Optical Bench
- · Shuttle Payload Bay Doors

The antenna structure ICI is the cost of raw materials only since the costs associated with fabrication and assembly are charged against orbital assembly and support equipment. The antenna structure ICI cost equation is based on raw composite material stock (prepregnated graphite) cost. These material costs are based on vendor quotes obtained from Hercules, Fiberrite and Union Carbide.

Range of Data:

D&D: 30,0 to 2000.0 kg

ICI: Unlimited

1.1.2.1.2 Secondary Structure

The secondary structure consists of the passive interface attachment between the primary structure and operational subsystems. The structural members are made of aluminum with the ability to articulate, rotate, or

otherwise support/allow motion between the primary structure and other subsystem elements.

This element includes all structure, consisting of mounting brackets, clamps and installation structure required as an interface and mounting attach points of components, assemblies, and subsystems. It also includes any structure required between two or more components or assemblies.

Development of the secondary structure CER for DDT&E was based on cost contained in the MSFC Redstar Data Base. Data from a variety of launch vehicle and unmanned sate-lite programs were available and the applicable data points are listed below:

- S-IVB Interstage
- S-IC Forward Skirt
- S-IC Intertank
- Solar Telescope Housing Assembly (ASM)
- Common Mount Assembly (ASM)
- Telescope Gimbal Assembly (ASM)
- Common Mount Actuators (ASM)
- Telescope Gimbal Actuators (ASM)
- Array Platform Elevation Pointing Actuator (ASM)
- UV Gimbal Mount Actuators (ASM)
- UV Instrument Mount Assembly (ASM)

- Solar Array and Boom Structure (ATS-F)
- Squib Interface Unit (ATS-F)
- Interstage (Centaur)
- Nose Shroud (Centaur)
- Fixed Airlock Shroud (Skylab)
- Payload Shroud (Skylab)
- Pallet Segment (Spacelab)
- OSO-1
- ATS-F
- · S-II

The ICI production cost CER was based upon an Engineering Cost estimate.

Range of Data:

DDT&E: 6.0 to 15,000.0 kg ICI: 6.0 to 15,000.0 kg

1.1.2.1.3 Cost Estimates

Input parameters T&M are in kilograms of mass, see Tables 1.1.2.1.1 and 1.1.2.1.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.1.1 PRIMARY STRUCTURE

		INPUT P	ARAMETERS			INPU	T COEFFICIENTS	
	T= 67	000.0000	- T-F-=	1.000000		CDCER=	0.023000	
		375.00000	=M30	0.0		CDEXP=	0.80000	· · · · · · · · · · · · · · · · · · ·
	CF=	1.000000	Z1 =	1.000000		CICER=	0.000050	
	PH I=	1.000000	Z 2=	60.000000		CIEXP=	1.000000	
	R=	0.002000	Z3=	60.000000				
	DF=	0.020000	Z4=	60.000000	25 =	. 0	•0	
	CAL CUL AT ED	VALUES	KG	SUM TO	1.1.2.1		\$, MILLIONS	
	CD=CDCER X (T X	DF)XX(CDEXP) X CF				7.301	
	CLRM=CICER X (M)XX(CIEXP) X	CF X TF				0.419	
)))	#RM =T / M						8.000	
i 	E =1.0 + LOG(PHI) / LOG(2	.0)				1.000	<u> </u>
	CTFU=(CLRM / E)	X((#RM X Z1+	.5)XX(E) -0	.5XX(E))			3.350	
	CTB = ((CLRM/E)X	((#RM X Z	3 + 0.5)XX(1	E) -0.5XX(E))		1 / 23	3.350	
	CIPS=CTB*Z4/Z2				 	enaganganaka nistra staabi angestana	3.350	
	CRCI = CTB	X R	<u> </u>				0.007	·
	CCEM = 08M	OR CT B*Z5/Z2	/ENYR				0.0	•

	ROCKWE	LL SPS CR-	2 REFERENCE	CONFIGURATION	
TABLE	1.1.2.1.2	SECONDARY	STRUCTURE		

	INPUT PARAMETERS	INPUT COEFFICIENTS					
	T= 234000.000 TF=	0.007300		CDCER=	0.15600	0	
	M= 5.000000 O&M=	0.0		CDEXP=	0.51100	0	
	CF= 1.000000 Z1=	1.000000		CICER=	0.10100	C	
	PHI= 0.980000 Z2=	60.000000		CIEXP=	0.35500	0	
	R= 0.002000 Z3=	60.000000					
	DF= 0.050000 Z4=	60.000000	Z5 =		• 0 • 0 • • • • • • • • • • • • • • • • •		
	CALCULATED VALUES KG	SUM TO	1.1.2.1			\$, MILLIONS)·
	CD=CDCER X (T X DF)XX(CDEXP) X CF		a de l'alle a marier de la company de l'alle			18.705	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF					0.001	
В	#RM =T / M				46800.00	0	
56	E =1.0 + LOG(PHI) / LOG(2.0)				0.97	1	•
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.	5XX(E))				45.999	
•.	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3		40 - 825	
	CIPS=CTB*Z4/Z2			promotypiska kang unita siga yani siya dina basanananging		40.825	
	CRCI =CTB X R					0.082	
	COEM = OEM OR CTB*Z5/Z2/ENYR					0.0	
	COMMENTS						

1.1.2.2 TRANSMITTER SUBARRAY/KLYSTRONS

This element includes all the hardware required for generation, distribution, phase control and radiation of microwave energy. This includes the subarray structure, wave guides, power amplifiers, control devices, and power harnesses. Also included are thermal control devices and finishes that are manufactured as an integral part of the subarray.

RF generators convert the direct current (dc) electric power to RF microwave power. Klystrons are used in this system as the high power RF transmitting devices. Wave guides receive the RF power from the generator and radiate it to the ground-based rectenna.

Historical data for some twenty phased array radars ranging over a period of the last twenty years were extracted from the Redstar Data Base and/or obtained from various contractors. The data were analyzed, normalized and the costs were adjusted to reflect 1977 dollars. In addition, for all costs utilized, the facility receiver subsystem hardware, data subsystem costs and basic facility/housing costs were removed.

The application of phased array radar costs to the development cost estimates of the microwave antenna was pertinent since the design and development of these physically large ground installations was conducted in much the same manner that is being utilized for the SPS. The ground array radiating elements were assembled in subarray panels, complete with the radiating elements, wave guide, and cabling. The subarrays were then mounted into the facility framework, subarray cabling, and plumbing connection completed at system level and confidence testing conducted. The same general assembly philosophy is expected to be followed for the microwave antenna, the difference being that the microwave antenna will be totally assembled in the space environment.

The D&D CER was based on data from four DOD classified projects identified only as Projects 21, 22, 23, and 24 as well as the Cobra Dane, AN/SPS-48 and SAM-D (PATRIOT) radar systems.

A different approach was taken to develop the TFU CERs. After reviewing the various radar systems' cost, it was determined that not enough insight was afforded into the components; therefore, a "grass-roots" approach was undertaken.

For purposes of developing a "grass-roots" estimate for the TFU, a segment of the antenna measuring 2.4 m² was assumed to be the Lowest Replaceable Unit (LRU). In addition, to arrive at an "average" LRU, it was necessary to evenly distribute all components over the antenna. Enclosed tables list the components and their estimated cost for both the klystron and amplitron configurations. The required components were determined through analysis. Letters and telephone calls were directed to hardware manufacturers requesting technical data and cost quotes for the specified components. Where multiple quotes were obtained, the average cost was used. In some instances, estimates had to be relied upon. It was further assumed that the components are the same in each configuration with only the power tubes changing with the exception of the klystron configuration where the IRF amplifier is different.

Data contained in the Redstar Data Base were utilized to develop integration factors which were added to the vendor quotes. To account for the cost associated with voltage measurement instrumentation for the microwave antenna, a 20% instrument factor was also applied to the vendor quotes. The individual cost estimates, developed for each type of power tube, were utilized to develop CERs based on the area of one LRU. For the purpose of developing these CERs, three different LRU sizes were assumed – 2.4 m 2 , 24 m 2 , and 240 m 2 . It is necessary for the user to determine the size and number of LRUs required for any given antenna configuration. It is also necessary for the user to consider any learning that may occur.

Range of Data:

D&D: 1000 to 100,000 kilowatts

ICI: Unlimited

Table 1.1.2.2.1 expresses the DDT&E cost estimate $[C_D=.067(P_T)^{0.507}(CF)]$ to facilitate the use of antenna power in kilowatts as the input factor. Table 1.1.2.2.2 shows the $C_{I,LRU}=.00327(A_{LRU})^{1.000}$ where A is in square meters. A complexity factor of 1.25 is used to compensate for the klystron kilowatt power rating as used in the data base.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.2.1 KLYSTRON DDT&E

		INPUT F	PARAMETERS		INPUT COEFFICIENTS				
	T=	6790000.00	TF=	1.000000	CDC ER =	0.205000			
	M=	6790000.00	=M3O	0.0	CDEXP=	0.507000			
	CF= PHI=	1.250000	Z1= Z2=	1.000000	CICER= CIEXP=	0.0			
ļ	PH 1= R=	0.980000	Z2= Z3=	180.000000	CIEXP	U.O			
- Augustus	DF=	0.020000	Z 4=	60.000000	Z5= 0.0				
-			2.						
	CALCU	LATED VALUES	KW	SUM TO 1.	1.2.2	\$, MILL IONS			
	CD=CDCER X	(T X DF)XX(CDEX) X CF			102.576			
TO THE REAL PROPERTY OF THE PR	CLRM=CICER	X (M)XX(CIEXP)	CF X TF			0.0			
В	#RM =T / M					1.000			
3-59	E = 1.0 +	LOG(PHI) / LOG(2	2.0)			0.971			
The special spaces of	CTFU=(CLRM	/ E)X((#RM X Z1	5)XX(E) -	0.5XX(E))		0.0			
	CTB = ((CLR	M/E)X((#RM X	23 + 0.5) XX	(E) -0.5XX(E)	1 / 23	0.0			
	CIPS=CTB*Z	4/22		ingginate-pulsus and antique in the pulsus and an antique and an antique and an and an antique and antique and an ique and an ique and antique and an antique and antique antique and antique antique and antique and antique and antique antiqu		0.0			
	CRCI	=CTB X R				0.0			
	CC&M =	OEM OR CTB*Z5/Z	2/ENYR			0.0			
	COMMENTS				manuschen und der State der St				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.2.2 KLYSTRON ICI, R. OEM

	그렇지 사람들이 살아를 가 가게 되는 것이 되었다.							
et mantinatemanis de	INPUT PARAMETE	RS	INPUT COEFFICIENTS					
	T= .830808.000 TF= M= 118.800003 O6M=	1.000000		CDCER=	0.0			
	CF= 1.250000 Z1= PHI= 0.980000 Z2=	1.000000		CICER= CIEXP=	0.0 0.003270 1.000000	•		
	R= 0.066667 Z3= DF= 0.020000 Z4=	180.000000 60.000000	25=	0.0		s author and a spain by haute who are used to and the and		
	CALCULATED VALUES SQ N	SUM TO	1.1.2.2		\$, MILLIONS			
	CD=CDCER X (T X DF)XX(CDEXP) X CF				0.0			
	CLRM=CICER X (M)XX(CIEXP) X CF X	r F			0.486			
	#RM =T / M				6993.332			
-60	E = 1.0 + LOG(PHI) / LOG(2.0)				0.971			
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))			2702.309			
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5	1XX(E) -0.5XX(E))) / Z3	2322.804			
	CIPS=CTB*Z4/Z2	n an an ann an an an an an an an an an a	Andrewski, proportion of the second section of the second	and the second s	2322.804	er - armi hidenining pin ngrekkumakinin aggan.		
	CRCI =CTB X R				154.854	· · · · · · · · · · · · · · · · · · ·		
	COEM = OEM OR CTB*Z5/Z2/ENYR				0.0			
	COMMENTS	eng mananan at ang pang mananan ang ang mananan naganan mananan dinagan di ang ang ang ang ang ang ang ang ang	and the second s	man real and extensive a series of the serie	samba rekalik arrandira, ini salayan wake sphalekingah yara ahaan na ki na na na ha yara ni mahkisin sur medaba			

1.1.2.3 POWER DISTRIBUTION AND CONDITIONING (PD&C)

This element includes the various power feeders, switching, and conditioning equipment s necessary to deliver power at the required voltage and power levels for the power transmission section (antenna portion) of the satellite. An energy storage system is included to supply power to keep the power transmission system at a ready state and for housekeeping requirements during eclipse periods. Data buses are not a part of this element as they are included in the information management and control subsystem (WBS No. 1.1.3).

The PD&C system receives power from the interface (Energy Conversion/Power Transmission) system and provides for the power conditioning and switching required to deliver the power, through the distribution network, to the microwave energy conversion units. On the rotating member, power is conducted through switch gears to dc/dc converters which output the six primary voltages required by the Klystrons. Each voltage is conducted to a summing bus through switch gears and power feeders and on through switch gear at the mechanical modules for use at the subarrays to provide power at the 135,864 Klystrons.

Batteries and battery conditioning equipment are included also to provide the stored energy to power the heater requirements which keep the Klystrons at a ready mode during the eclipse periods. The batteries will also provide power for the necessary housekeeping activities, i.e., stationkeeping, IMCS, TT&C, etc., during this period.

1.1.2.3.1 Switches and Power Conditioning.

Switches will be used to perform operational functions as monitored through the IMCS. Switch gears will:

- Isolate converters, main feeders, secondary feeders, mechanical modules, subarrays and Klystrons for maintenance work
- Provide split bus power feed to offer redundancy to some modules in event of failure of a converter or summing bus
- · Control power through the IMCS for:
 - short circuit protection
 - systematic start-up and shut-downs to prevent surges during eclipse periods
 - · control various loads

The basic switches will be of the Penning cross-field tube design and monitored and controlled by the IMCS. The IMCS will will determine their status and functionally connect them to the proper feeder and summing bus as conditions may direct.

The power converter and conditioners convert the existing bus voltages to the subsystem voltage required for the various subsystem loads. The output tolerances will be based on using subsystem interface requirements. The power converters are utilized in the GEO mode of operation.

1.1.2.3.2 Conductors and Insulation

The summing buses, main feeders and secondary feeders are generally sized to minimize the combined mass of itself and the satellite mass, considering the power requirements, efficiency, and variation in resistivity with temperature. The PD&C utilized aluminum (6101-T6) conductors.

1.1.2.3.3 Batteries

Batteries will be utilized during the ecliptic periods to provide minimum energy to keep the Klystrons warmed to a ready state and as necessary during the required housekeeping tasks. The batteries will be a sodium chloride type having the capability of providing 200 watt hours/kg.

The battery PD&C costing is included in the earlier sections of 1.1.2.3.2 and 1.1.2.3.1. This element consists of the mechanisms for the charging of batteries and the distribution and regulation of power to and from the battery. This function will be monitored and controlled by the IMCS. Included are the battery chargers, power regulators, diodes, power regulators, and power conditioning equipment that directly interfaces with the battery system.

1.1.2.3.4 PD&C Cost Estimates

The CER's used in this section are the same as those described in Section 1.1.1.4. The following tables itemize the design/cost parameters and identify the cost estimates in each area.

Table	Description
1.1.2.3.1	Switch Gear and Converters
1.1.2.3.2	Conductors and Insulation
1.1.2.3.3	Batteries

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.3.1 SWITCH GEAR & CONVERTERS

		INPUT F	ARAMETERS			IN	IPUT COEF	FICIENTS	
	1=	1901000.00	TF=	1.000000		DCER=		0.158000	
	M= CF=	2447.00000 1.500000	0 & M = Z 1 =	0.0 1.000000	C	DEXP=		0.297000 0.000400	
	PH I = R = DF =	0.950000 0.066667 0.050000	Z2= Z3= Z4=	60.000000 180.000000 60.000000	Z5 =	IEXP=	0.0	1.000000	
		LATED VALUES	KG	SUM TO 1				\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF					7.132	The second secon
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					1.468	
в-63	#RM =T / M							776.870	
<u> </u>		/ E)X((#RM X Z1+		0.5XX(E))				0.926 752.336	
	CTB = ((CLR	M/E)X((#RM X Z	3 + 0.51XX	((E) -0.5XX(E))) / Z3		512.556	
-	CIPS=CTB*Z	4/22		***	ORIGINAL OF POOR	<u> </u>		512.556	
	CRCI	=CTB X R			POG	·	· · · · · · · · · · · · · · · · · · ·	34.171	
		0&M OR CTB*Z5/Z2	/ENYR		R QUALI			0.0	
	COMMENTS				ALITY ALITY				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.3.2 CONDUCTORS & INSULATION

				graphical and the second secon			any amin'ny go ny hana na and na any analana ao na na ananana na na ananana ao ana ana	
		NPUT PARAMETERS			IN	PUT COE	FFICIENTS	
	T= 1337000.00	TF=	1.000000		CDCER=		0.158000	
	M= 1720.00		0.0		CDEXP=		0.297000	
	CF= 1.00		1.000000		CICER=		0.00004	
	PHI= 1.00		60.000000		CIEXP=		1.000000	
	R= 0.0	73=	60.000000	3 5 -		0.0		
	DF= 0.10	0000 Z 4=	60.000000	25 =		0.0		
	CALCULATED VALUE	S KG	SUM TO	1.1.2.3			\$, MILLIONS	
. appears with take to the o	CD=CDCER X (T X DF)XX	(CDEXP) X CF			everipakis ve e bi qi isadqeesh		5.262	
	CLRM=CICER X (M)XX(CI	EXP) X CF X TF					0.007	
₽	#RM =T / M						777.325	
64	E =1.0 + LOG(PHI) /	LOG(2.0)					1.000	
	CTFU= (CLRM / E)X((#RM	X Z1+.5)XX(E) -0	.5XX(E))				5.348	
	CTB =((CLRM/E)X((#RM	X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3		5.348	
	CIPS=CTB*Z4/Z2		entre programme de la companya del companya de la companya del companya de la companya del la companya de la co				5.348	
	CRCI = CTB X R						0.0	
	COEM = OEM OR CTB	*25/22/ENYR					0.0	
	COMMENTS		ما ما الما الما الما الما الما الما الم		يوسود الميدي يوسود الميدي المواجد الموسود	Antonio (Agino)		

ROCKI	VELL SPS	CR-2	REFERENCE	CONFIGURATION	_
TABLE 1.1.2.3.3	BATTER	I E S			

31 •						
	INPUT PARAMETERS	INPUT COE	FICIENTS			
	T= 190000.000 TF= 0.075000	CDCER=	0.0			
	M= 50.000000 DεM= 0.475000	CDEXP=	0.0			
	CF= 1.000000 Z1= 1.000000	CICER=	0.028000			
	PHI= 0.950000 Z2= 60.000000	CIEXP=	0.241000			
	R= 0.033333 Z3= 120.000000					
	DF= 1.000000 Z4= 60.000000	Z5= 0.0				
	CALCULATED VALUES KG SUM TO	1.1.2.3	\$, MILLIONS			
! !	CD=CDCER X (T X DF)XX(CDEXP) X CF		0.0			
	CLRM=CICER X (M)XX(CIEXP) X CF X TF		0.005			
ᄧ	#RM =T / M		3800.000			
65	E =1.0 + LOG(PHI) / LOG(2.0)		0.926			
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))		12.115			
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))	1 / 23	8.502			
	CIPS=CT8*Z4/Z2		8.502			
	CRCI = CTB X R	R	0.283			
	CO&M = O&M OR CTB*Z5/Z2/ENYR	OF POOR	0.475			
	COMMENTS BATTERY PD&C INCLUED IN 1.1.2.3.1 & 1.1.2.3.2	QUALITY				
		20				

1.1.2.4 THERMAL CONTROL

This element includes any component used to modify the temperature of power transmission subsystem components. It includes cold plates, heat transfer and radiator devices as well as insulation, thermal control coatings and finishes. Excluded are paints and finishes applied to components during during their manufacturing sequence and thermal control devices that are an integral part of another component.

The multi-layer insulation panels are required for the back surface of the resonant cavity radiators to restrict waste heat leaks which could increase temperatures of electronics to unacceptable levels. This insulation is coated externally with low absorptivity/emissivity materials to limit the absorbed solar flux to which the surface is exposed during part of the orbit.

The insulation CER's are based upon secondary structure CER's where the secondary structure CER's were considered comparable to the requirements of insulation in its application on the antenna.

Table 1.1.2.4 presents cost estimates for thermal control.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.4 THERMAL CONTROL - INSULATION

	INPUT	PARAMETERS		INPUT COEFFICIENTS					
T=	557000.000	TF=	0.012400	CDCER=	0.156000				
M=	4.000000	=M30	0.0	CDEXP=	0.511000				
CF=	1.000000	Z1=	1.000000	CICER=	0.101000				
PHI=		Z2=	60.000000	CIEXP=	0.355000				
R=	0.010000	Z3=	60.00000						
DF=	0.050000	Z4=	60.000000	25 = 0.0					
CAI	CULATED VALUES	KG	SUM TO 1.	1.2	\$, MILL TONS				
CD=CDCE	R X (T X DF)XX(CDEX) X CF			29.136	ا میش در دری میمیمیشی مینیسی میداشد.			
CLRM=CI	CER X (M)XX(CIEXP)	X CF X TF			0.002				
B- #RM = T	/ M				139250.000				
E =1.	+ LOG(PHI) / LOG(2.0)			0.971				
CT FU= (CI	RM / E)X((#RM X Z1	+.5)XX(E) -	0.5XX(E))		208.062				
CTB = ((CLRM/E)X((#RM X	Z3 + 0.51XX	(E) -0.5XX(E))	1 / Z3	184.657	*			
CIPS=CT	B*Z4/Z2	and the second s			184.657	an an an angganggang an ang an an ang ang			
CRC	I =CTB X R				1.847				
	M = O&M OR CTB*Z5/Z	2/ENYR			0.0				
COMMENT									

1.1.2.5 CONTROL-PHASE REFERENCE

This element provides the reference phase for all subarray phase conjugating circuits and includes the reference oscillator signal distribution, and frequency conversion equipment. It covers components/equipment that commonly serve all subarrays.

The transmitted signal is formed from the pilot beam by means of the retroelectronics where one circuit is required per subarray. A servo system is needed to transfer the required reference phase from a central point to a mechanical module, where it is distributed to the nine subarrays. The main items included in this subsystem are shown in Table 1.1.2.5.

WBS ITEM/ OUANTITY NO'. DESCRIPTION PER SATELLITE REFERENCE FREQUENCY GENERATOR 1 SET (777 POWER 1.1.2.5.1 AMPLIFIERS, 1-4 REGULATORS) 1.1.2.5.2 COAX CABLE 777 SETS 1.1.2.5.3 DEVICES FOR USE ON FREQUENCY 777 SETS DISTRIBUTION SYSTEM

Table 1.1.2.5 Control-Phase Reference

Tables 1.1.2.5.1, 1.1.2.5.2 and 1.1.2.5.3 present the engineering estimates for these items.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.5.1 REFERENCE FREQUENCY GENERATOR

		INPUT P	ARAMETERS		INPUT	COEFFICIENTS	
		1.000000	TF=	1.000000	CDCER=	0.500000	<u> </u>
	M= C F=	1.000000	0&M=	0.010000	CDEXP= CICER=	1.00000 0.10000	
	CF= PHI=	1.000000	Z1= Z2=	1.000000 60.000000	CIEXP=	1.00000	
-	R=	0.033333	Z3=	120.000000	OI CX. —	1.00000	
	DF=	0.200000	Z4=	60.000000	Z5 = 0.0		
			-				
	CALCULATED	VALUES -	SET	SUM TO 1.	1.2.5	\$, MILLIONS	
	CD=CDCER X (T X	DF)XX(CDEXP) X CF			0.100	
	CLRM=CICER X (M)XX(CIEXP) X	CF X TF			0.100	
₽	#RM =T / M					1.000	
-69	E = 1.0 + LOG(PHI) / LOG(2	.0)			1.000	· · · · · · · · · · · · · · · · · · ·
	CTFU=(CLRM / E)	X((#RM X Z1+	.5)XX(E) -(0.5XX(E))		0.100	, · · · · · · · · · · · · · · · · · · ·
1	CTB = ((CLRM/E)X	((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3	0.100	
	CIPS=CTB*Z4/Z2			<u> </u>		0.100	
1 0 1 <u></u>	CRCI =CTB	X R 1				0.003	
	M30 = M303	OR CTB*25/22	/ENYR			0.010	•
	COMMENTS						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.5.2 DIST. SYSTEM, COAXIAL CABLE

		INPUT P	ARAMETERS			IN	PUT COE	FFICIENTS	y managamatan managamatan managamatan managamatan managamatan managamatan managamatan managamatan managamatan
		203000.000	TF=	1.000000		CDCER =		0.00005	
	M=	261.000000	=M3C	0.0		CDEXP=		1.00000	
	CF=	1.000000	Z1=	1.000000		CICER=		0.000060	
	PHI=	1.000000	Z 2=	60.000000		CIEXP=		1.000000	
	R=	0.0	23=	60.000000					····
	DF=	0.200000	Z 4=	60-000000	Z5 =		0.0		
	CALCUI	LATED VALUES	M 1	SUM TO	1.1.2.5			\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF	المنافعة المعالمة الم	N-10-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1	and the second of the second o	· · · · · · · · · · · · · · · · · · ·	0.203	e no a com no especial mesesper estigis also
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					0.016	
В	#RM =T / M							777.778	
-70	E =1.0 +	LOG(PHI) / LOG(2	.0)					1.000	
	CTFU={CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				12.180	
	CTB = ((CLR	M/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3		12.180	
	CIPS=CTB*Z	4/22				**************************************		12.180	
	CRCI =	CTB X R						0.0	
	C C & M =	O&M OR CTB*Z5/Z2	/ENYR					0.0	
	COMMENTS								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.5.3 DIST. SYSTEM, DEVICES

	INPUT PARAMETERS	I NPUT COE	FFICIENTS
	T= 1554.00000 TF= M= 2.000000 0&M= CF= 1.000000 Z1= PHI= 1.000000 Z2=	1.000000 CDCER= 0.0 CDEXP= 1.000000 CICER= 60.000000 CIEXP=	0.000225 1.000000 0.005000 1.000000
	R= 0.033333 Z3= DF= 0.200000 Z4=	120.000000 60.000000 Z5= 0.0	
	CALCULATED VALUES KG CD=CDCER X (T X DF)XX(CDEXP) X CF	SUM TO 1.1.2.5	\$, MILL IONS 0.070
	CLRM=CICER X (M)XX(CIEXP) X CF X TF		0.010
B-71	#RM =T / M E =1.0 + LOG(PHI) / LOG(2.0)		777.000 1.000
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -	-0.5XX(E))	7.770
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)X)	X(E) -0.5XX(E)) / Z3	7.770
	CIPS=CTB*Z4/Z2		7.770
	CRCI = CTB X R CO&M = O&M OR CTB*Z5/Z2/ENYR		0.259
	COMMENTS		

1.1.2.6 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and insitu repair equipment.

Maintenance requirements of this element are related to the power transmission (antenna) section of the satellite covering the structures; subarrays (Klystrons); power distribution/conditioning and energy storage; thermal control, and control elements. Some of the maintenance equipment are multipurpose and are therefore costed against the applicable maintenance items on an apportioned basis.

Maintenance requirements for this element are presented in Table 1.1.2.6 and cost estimates are projected in Tables 1.1.2.6.1, 1.1.2.6.2, 1.1.2.6.3, and 1.1.2.6.4.

Table 1.1.2.6 Maintenance Requirements

	•	,		
WBS NO.	MAINTENANCE ITEM DESCRIPTION	1.1.2.6 POWER TRANSMISSION		
1.1.2.6.1	''FREE-FLYERS'' OR BARGE FOR CARGO AND PERSONNEL (COMMON USE ITEM)	1 VEHICLE UTILIZATION		
1.1.2.6.2	GANTRY CRANE AT ANTENNA	SET		
1.1.2.6.3	ON-CRANE CONTROL CENTER, HOISTS, EQUIPMENT TEST GEAR, ROBOTICALS	SET		
1.1.2.6.4	TRACKS AND ACCESSWAYS	12000 kg		

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.6.1 MAINTENANCE - FREE FLYERS

		INPUT P	ARAMETERS			INPUT COEFF	FICIENTS	
		5000.00000	TF=	1.000000	CDCER	=	0.0	
	M=	5000.00000	=M30	0.0	CDEXP		0.0	
	CF=	1.250000	Z 1 =	1.000000	CICER	the state of the s	0.005798	
	PH [=	0.950000	Z2=	60.000000	CIEXP	=	1.000000	
	R=	0.020000		60.000000				
	DF=	1.000000	Z 4=	60.000000	Z5 =	0.0		
	CALCUL	ATED VALUES	KG	SUM TO 1.	1.2.6		\$, MILLIONS	: ** *
	CD=CDCER X	(T X DF)XX(CDEXP	X CF		in which with the control of the con		0.0	· · · · · · · · · · · · · · · · · · ·
	CLRM=CICER	X (M)XX(CIEXP)	CF X TF				36.238	•
ᅜ	#RM =T / M						1.000	
73	E = 1.0 +	LOG(PHI) / LOG(2	.0)			· · · · · · · · · · · · · · · · · · ·	0.926	
	CTFU= (CLRM	/ E)X((#RM X Z1+	5)XX(E) -	0.5XX(E))			36.368	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))		Z3	28.784	
	CIPS=CTB*Z4	/22					28.784	
	CRCI =	CTB X R					0.576	
	CO&M =	O&M OR CTB*Z5/Z2	?/ENYR				0.0	
-	COMMENTS		gada a la cominate de la cominate d					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.2.6.2 GANTRY CRANE

		INPUT P	ARAMETERS	the constant is a constant. The state place constant account of the constant particle product product and constant account of the constant particle		INPUT CO	DEFFICIENTS	The state of the s
	T=	40000.0000 40000.0000	==T ==M30	1.000000		CDCER=	0.234000	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	CF= PHI=	1.100000	Z1= Z2=	1.000000		CICER= CIEXP=	0.000005 1.000000	
	R= DF=	0.002000 0.200000	Z3= Z4=	60.000000	Z5 =	0.0		
·	CALCUL	ATED VALUES	KG	SUM TO	1.1.2.6	A CONTRACTOR OF THE PARTY OF TH	\$, MILLIONS	
1	CD=CDCER X	(T X DF)XX(CDEXP) X CF		and the second of the second o		91.060	and the second s
	CLRM=CICER	X (M)XX(CIEXP)	CF X TF				0.220	
ᄧ	#RM = T / M						1.000	
74	E = 1.0 +	LOG(PHI) / LOG(2	.0)				1.000	
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))			0.220	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))	in at the second) / Z3	0.220	
	CIPS=CTB*Z4	/72	THE RESERVE THE PROPERTY OF THE PARTY OF THE	ne see en uitamus en en e <mark>n en /mark>		eren dari egi kalami je pili na nip araninga taki n masemining simala.	0.220	A Maryan — A Marie a Marie and A Angel and A Marie a
	CRCI =	CTB X R		en e			0.000	· · · · · · · · · · · · · · · · · · ·
	COEM =	0&M OR CTB*Z5/Z2	/ENYR				0.0	
	COMMENTS					terren erre desember ett såtet i en søde ett sætte sette sætte sætte sætte sætte sætte sætte sætte sætte sætte	alamandad o a comanda a comanda de comanda de comanda de com anda de comanda	······································

	ROCKWELL	SPS CR-2	REFERE	NCE CO	NFIGURATION
TABLE 1.1.2	2.6.3 ON-	CRANE CO	INTROL C	ENTER	

. 21 ~

	INPUT P	ARAMETERS	, recognition of the designate culture rates and secure and definitions of the Milliannian columnian.		IN	PUT CO	EFFICIENTS	· · · · · · · · · · · · · · · · · · ·
τ=	50000.0000	TF=	1.000000		CDC ER=		0.012432	
M=	50000.0000	=M30	0.0		CDEXP=		1.00000	
C F=	1.000000	Z1=	0.100000		CICER=		0.005798	
PHI=	0.950000	Z 2=	60.000000		CIEXP=		1.000000	
R=	0.020000	Z3=	6.000000					
DF=	1.000000	Z4=	6.000000	Z 5=		0.0		
CALCU	LATED VALUES	KG	SUM TO	1.1.2.6			\$, MILLIONS	··· · · · · · · · · · · · · · · · · ·
CD=CDCER X	(T X DF)XX(CDEXP) X CF					621.600	
CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					289.900	
균 #RM =T / M	:						1.000	
7	LOG(PHI) / LOG(2	.0)					0.926	
CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				30.305	
CTB = ({CLR	M/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3		267.824	
CIPS=CTB*Z	4/72	add nathroceann air e abanna ann a mainte agus na 1864, agus				TO THE PROPERTY OF THE PARTY OF	26.782	
CRCI	=CTB X R						5.356	
CC&M =	O&M OR CTB*Z5/Z2	/ENYR					0.0	
COMMENTS							erendekine er er in de frigueren, de 4 delende en figstele gener med herbe demann der kommunen men er unsern de abstele blevæntet.	

ROCKWELL SPS	CR-2 REFERENCE CONFIGURATION
TABLE 1.1.2.6.4 TRACKS	& ACCESS WAYS

		INPUT P	ARAMETERS		Andreas Services (Services Services Services Services Services Services Services Services Services Services Se	IN	PUT CO	EFFICIENTS
	₹=	12000.0000	TF=	1.000000		CDCER=		0.0
	M=	12000.0000	=M30	0.0		CDEXP=		0.0
•	CF=	1.000000	Z1=	1.000000		CICER=		0.000005
	PHI=	1.000000	Z 2 =	60.000000		CIEXP=		1.000000
	R=	0.002000	Z3=	60.000000				
	DF=	1.000000	Z 4=	60.000000	Z5 =		0.0	
	CALCULA	TED VALUES	KG	SUM TO	1.1.2.6	· · · · · · · · · · · · · · · · · · ·		\$, MILL IONS
<u>CD</u>	=CDCER X (T X DF)XX(CDEXP) X CF		portuning producers are an are appeared to 1 th or 1 th 1 t	the control of the party and the control of the con	iga na pilong ng ng ng pigibilipang pangan ngangg	0.0
CL	RM=CICER X	(M)XX(CIEXP) X	CF X TF					0.060
#R	M = T / M							1.000
B-176 E	=1.0 + L	OG(PHI) / LOG(2	.0)					1.000
CT	FU=(CLRM /	E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))				0.060
ст	B = ((CLRM/	E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		0.060
CI	PS=CTB*24/	72	And the second s	e en	-			0.060
	CRCI = C	TB X R						0.000
	C CE M = 0	EM OR CTB*Z5/Z2	/ENYR					0.0
CO	MMENTS		19 - 19 - 19 - 19 - 19 - 19 - 19 - 19 -	The second secon				and the second s



1.1.3 INFORMATION MANAGEMENT AND CONTROL

This element includes those components that process information onboard the satellite. This includes sensing, signal conditioning, formatting, computations, and signal routing.

The information management and control subsystem (IMCS) provides the interconnecting elements between and within all the various satellites and ground-based operational subsystems. The IMCS also provides operational control of both the satellite and ground systems as well as providing all subsystem processing support for all but very special functions.

The satellite IMCS consists of the on-board processing equipment [central processing units (CPU) and memories], the inter- and intra-subsystem data network (data buses), the man-machine interfaces (display/control), and intersystem communication links, including RF, but excepting those specifically provided for the control and transfer of primary power, and all elements provided to accommodate activities related to system security, safety, or any other operation necessary to the continuing operation of the SP3.

Because of the early stage of program analysis, only those requirements imposed upon the IMCS by a limited number of satellite operations have been identified. The identified requirements generally are limited to those associated with the immediate operations of an active satellite. Auxiliary functions such as ground/space communications, display/control, safety, security, etc., will be added when data become available.

The usage and application of IMCS items is identified in Table 1.1-3 and provides direct association with the subsystem functions.

	INSTRUMENTATION	DATA ACQUISITION	DATA PROCESSING	CONTROL	
ELEMENT Description	SENSORS SIGNAL CONDITIONING	SOFTWARE SIGNAL ROUTING	SOFTWARE FORMATT ING COMPUTATION DISPLAY GENERATION	DISPLAYS & CONTROLS SIGNAL CONDITIONING	WBS NO.
MASTER CONTROL COMPUTER			x		1.1.3.1
DISPLAYS CONTROL			x x x x	X	1.1.3.2
SUPERVISORY COMPUTER			xxx		1.1.3.3
REMOTE COMPUTER			xxx		1.1.3.4
BUS CONTROL UNIT		x x	x x x		1.1.3.5
MICROPROCESSORS			xxx		1.1.3.6
REMOTE ACQ. & CONTROL		x x	xxx	, x	1.1.3.7
SUB-MULTIPLEXER		x x	ххх		1.1.3.8
INSTRUMENTATION	x x				1.1.3.9
FIBER OPTICS		x			1.1.3.10
CABLES & HARNESSES	X X	X X	xxxx	X X	1.1.3.11

Table 1.1-3. Usage/Application Matrix per Satellite

These items have been separated into general hardware groups for costing purposes.

COMPUTERS

Historical cost data were obtained for computers from the Redstar Data Base system and are listed below:

• Gemini-3

Viking Lander

· Minuteman

• MOL

Skylab

• HEAO

A 50% integration factor was included in the DDT&E CER's to allow for subsystem level costs.

Range of Data:

DDT&E and ICI: 1.8 to 75.7 kilograms

ELECTRONIC COMPONENTS

The electronic components associated with Avionics include the Submultiplexors, Remote Acquisition Units, Microprocessors, Bus Control Units and instrumentation.

Development of an electronic components CER was based on the selected components of the ATS-F and OSO-8 spacecraft. These 19 electronic components are listed below:

ATS-F

Aux. Digital Sun Sensors Monopulse Unit

Wide Band Data Unit C Band Data Unit

S/L Band Transmitter VHF Receiver

Command Decoder

Data Acq. & Control Unit

Data Switching Unit

0S0-8

Solar Power Supply

Power Supply

Control Decoder/Demodulator

Remote Decoder PCM Decoder

Format Generator

Wheel Clock Sail Clock

S Band Transmitter VHF Transmitter

Range of Data:

DDT&E and ICI: 1.1 to 19.6 kilograms

DATA BUS

This element consists of both copper wire and fiber optics. Historical cost data were obtained from the Redstar Data Base to produce the data bus DDT&E CER. Commercial prices were used for the data bus ICI CER.

Production cost information obtained from private industry for "off-the-shelf" fiber optics and copper wire are listed below:

FIBER OPTICS:

Manufacturer	Type	Characteristics	Cost per Meter
ITT Electro-Optical	GG-02	Single Fiber	(1-10 km)
Products Division		50 m Dia.	\$3.25
	GS-02	Single Fiber	\$2.50
	3	50 m Dia.	
Valtec Fiberoptics	MG-05	Single Fiber	\$2.50
Division		65 m Dia.	
Galileo Electro-	** = ****	Single Fiber	\$1.58
Optics Corporation		88 m Dia.	
	Average	cost per meter	\$2.40

One industry spokesman estimates that the cost of optical fibers would likely decrease to 40% by 1980. This study assumes a \$2.40 per meter average price reduced by 40% to \$1.44 per meter.

COPPER WIRE:

Manufacturer		Characteristics	Cost per Meter
Dearborn Wire & Cable		22 gage stranded silver plate	\$0.807
Standard Wire & Cable		22 gage stranded silver plate	\$0.705
Karen, Inc.		22 gage, 2 conductor silver plate	\$0.807
Mil-Spec Wire & Cable Corporation		22 gage, 19-30 stranded	\$0.610
	Average c	ost per meter	\$0.732

Instrumentation input parameters T&M are in kilograms.

Cost estimates for the items of Table 1.1-3 are presented in Tables 1.1.3.1 through 1.1.3.11 inclusive.

				ROCKW	ELL SPS	CR-2 REI	FERENCE CON	FIGURATION
T	AB	LE	1.1	.3.1	MASTER	CONTROL	CCMPUTER	

	INPUT F	ARAMETERS		INPUT CO	EFFICIENTS	
	T= 1000.00000	TF=	0.900000	CDCER=	0.633000	
	M= 500.000000	=M30	0.0	CDEXP=	0.521000	
	CF= 1.000000	Z 1 =	1.000000	CICER=	0.172000	
	PHI= 0.800000	Z 2 =	60.000000	CIEXP=	0.535000	
	R= 0.010000	Z3=	60.000000			
	DF= 0.500000	Z 4=	60.000000	Z5 = 0.0		
	CALCULATED VALUES	KG	SUM TO	1.1.3	\$, MILLIONS	
	CD=CDCER X (T X DF)XX(CDEXF) X CF		The second secon	16.127	e a magazi manaman ya manaman kanaman
	CLRM=CICER X (M)XX(CIEXP)	CF X TF			4.302	
	#RM =T / M				2.000	· · · · · · · · · · · · · · · · · · ·
	E =1.0 + LOG(PHI) / LOG(2	2.0)			0.678	- A Chapter of the Control of the Co
	CTFU=(CLRM / E)X((#RM X Z14	5)XX(E) -0	.5XX(E))		7.845	
	CTB = ((CLRM/E)X((#RM X Z	23 + 0.5)XX(E) -0.5XX(E))) / 23	2.659	
· .	CIPS=CTB*Z4/Z2				2.659	
	CRCI = CTB X R				0.027	·
	CC&M = O&M OR CTB*Z5/Z2	2/ENYR			0.0	

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.3.2 DISPLAYS & CONTROLS

	INPUT PARAMETERS			INPUT	COEFFICIENTS
	T= 200.000000 TF= 0	.900000		CDCER=	0.102000
	M= 200.000000 O&M= 0	0.0		CDEXP=	0.879000
	CF= 1.000000 Z1= 1	.000000		CICER=	0.069000
		-000000		CIEXP=	0.557000
		.000000			
	DF= 1.000000 Z4= 60	.000000	Z5 =	0.	
	CALCULATED VALUES KG	SUM TO	1.1.3		\$, MILLIONS
	CD=CDCER X (T X DF)XX(CDEXP) X CF				10.745
	CLRM=CICER X (M)XX(CIEXP) X CF X TF				1.188
ᅜ	#RM = T / M				1.000
3-81	E = 1.0 + LOG(PHI) / LOG(2.0)				0.678
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))			1.211
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.	5XX(E))) / Z3	0.453
	CIPS= CTB* Z4/Z2				0.453
	CRCI =CTB X R				0.005
	COEM = OEM OR CTB*Z5/Z2/ENYR				0.0
	COMMENTS				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.1.3.3 SUPERVISORY COMPUTER

		INPUT P	ARAMETERS			INP	UT COEFF	ICIENTS	
		84.000000	TF=	0.700000		CDCER=		0.633000	
	M=	14.000000	=M30	0.0		CDEXP=		0.521000	
	C F=	1.000000	Z1=	1.000000		CICER=		0.172000	
	PH I=	0.850000	Z 2=	60.000000		CIEXP=		0.535000	
	R=	0.010000	Z3=	60.000000		•			
	DF≃	0.200000	Z4=	60.000000	25=		0.0		
	CALCULA	TED VALUES	KG	SUM TO 1	.1.3	Taran Salah. Kacamatan		\$, MILLIONS	
in .	CD=CDCER X (T X DF)XX(CDEXP) X CF					2.753	
	CLRM=CICER X	(M)XX(CIEXP) X	CF X TF					0.494	
- B	#RM =T / M							6.000	
82	E =1.0 + L	OG(PHI) / LOG(2	.0)					0.766	
	CTFU=(CLRM /	E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				2.325	
	CTB =((CLRM/	E)X((#RM X Z	3 + 0.51XX	(E) -0.5XX(E))) / Z3		0.969	
	CIPS=CTB*Z4/	72		<u> </u>				0.969	
	CRCI =C	TB X R						0.010	. ·
	COEM = O	&M OR CTB*Z5/Z2	∕ENYR					0.0	
	COMMENTS	and the second s						والمتحدد	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.3.4 REMOTE COMPUTER

그 그는 물문이 원래를 문자는 악하면 하다면 하는데 그 보는 그리고 하는데 그리는데 그리는데 그리고 하는데 그리고 하는데 그리고 있다.	
INPUT PARAMETERS	INPUT COEFFICIENTS
	CER= 0.633000 XP= 0.521000
CF= 1.000000 Z1= 1.000000 CIC PHI= 0.850000 Z2= 60.000000 CIE	ER = 0.172000 EXP = 0.535000
R= 0.010000 Z3= 60.000000 DF= 0.030000 Z4= 60.000000 Z5=	0.0
CALCULATED VALUES KG SUM TO 1.1.3	\$, MILL IONS
CD=CDCER X (T X DF)XX(CDEXP) X CF	2.643
CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.282
₩ #RM =T / M	37.000
$\stackrel{\circ}{\omega}$ E =1.0 + LOG(PHI) / LOG(2.0)	0.766
CTFU={CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)}	5.696
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))	/ Z3 2.238
CIPS=CTB*Z4/Z2	2.238
CRCI =CTB X R	0.022
CO&M = O&M OR CTB*Z5/Z2/ENYR	0.0
COMMENTS	앞당하다 본 일본 경화 남자의 이 보고 있는 그 그 사고 있다.

	ROCKWELL SPS CR-2	REFERENCE	CONFIGURATION	
TABLE	1.1.3.5 BUS CONTROL	UNIT		

 \bigcirc

	INPUT P	ARAMETERS	ture en communitar la 1940 e ministrativa d'un "established en dira empira estima discharación que en que en c		INPUT	T COEFFICIENTS	
T =	4110.00000	TF=	0.076000	CC	CER=	0.102000	
M=	5.000000	=M30	0.0	CE	EXP=	0.879000	
CF=	1.000000	Z1=	1.000000	CI	CER=	0.069000	
PHI=	0.950000	Z 2=	60.000000		EXP=	0.557000	
R=	0.010000	Z3=	60.000000				
DF≒	0.001200	Z 4=	60.000000	25 =	0.	•0	
CALCU	ILATED VALUES	KG	SUM TO 1.	1.3		\$, MILLIONS	
CD=CDCER X	((T X DF)XX(CDEXP) <u>X CF</u>				0.415	
.CLRM=CICER	R X (M)XX(CIEXP) X	CF X TF				0.013	
#RM =T / M		· · · · · · · · · · · · · · · · · · ·				822.000	
#RM =T / N E = 1.0 +	- LOG(PHI) / LOG(2	.0) 98.35.44			•	0.926	
CTFU=(CLRM	1 / E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			6.940	
CTB =((CLR	RM/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E)))	/ Z3	5.128	
CIPS=CTB*Z	4/72					5.128	
CRCI	=CTB X R					0.051	
CO&M =	0&M OR CTB*Z5/Z2	/ENYR				0.0	
COMMENTS						propriedures processor est. Telebook activista de la processor de la companya del companya de la companya de la companya del companya de la companya del la companya de la	· · · · · · · · · · · · · · · · · · ·

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.3.6 MICROPROCESSORS

		INPUT, P	ARAMETERS			IN	PUT COEF	FICIENTS	
		3960.00000	TF=	0.078000		CDCER=		0.102000	· · · · · · · · · · · · · · · · · · ·
	M=	5.000000	=M3O	0.0		CDEXP=		0-879000	1
	CF=	1.000000	Z1=	1.000000		CICER=		0.069000	
	PH I=	0.950000	Z 2=	60.000000		CIEXP=		0.557000	
	R≔	0.010000	Z3=	60.000000			4		
	DF≔	0.001300	Z 4=	60.000000	25 =		0.0		
	CALCUL	ATED VALUES	KG	SUM TO	1.1.3			\$, MILL IO	NS ;
	CD=CDCER X	(T X DF)XX(CDEXP) X CF					0.431	
·	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					0.013	
ಹ	#RM =T / M							792.000	
3-85	E =1.0 + (LOG(PHI) / LOG(2	.0)					0.926	د از در ا
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E)	-0.5XX(E))				6.881	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)X	X(E) -0.5XX(E))) / Z3		5.085	
	CIPS=CTB+Z4	/22						5.085	
	CRCI =	CTB X R						0.051	
		O&M OR CTB*Z5/Z2	/ENYR					0.0	
	COMMENTS								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.3.7 REMOTE ACQUISITION & CONTROL

		INPUT P	ARAMETERS		objectivities and debterm of debter in the debter for the	INPUT	COEFFICIENTS	
	7 T=	4925.00000	TF=	0.069000		CDC ER=	0.102000	
	M=	5.000000	=M30	0.0	•	CDEXP=	0.879000	
	CF=	1.000000	Z1 =	1.000000		CICER=	0.069000	
	PHI=	0.950000	Z 2=	60.000000		CIEXP=	0.557000	
	R=	0.010000	Z 3 =	60.000000				
	DF=	0.001000	Z 4=	60.000000	Z5 =	0.0		
	CALCUL	ATED VALUES	KG	SUM TO	1.1.3		\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF				0.414	
	CLRM=CICER	X (M)XX(CIEXP) >	CF X TF				0.012	
는 변	#RM =T / M						985.000	
g, 8	E =1.0 +	LOG(PHI) / LOG(2	.0)			and the second s	0.926	niae amang te an amin'ny disapa
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			7.450	
	CTB =((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	5.505	
	.CIPS=CTB*Z4	/22				naga a mara a mara a maray ana ina aga magamanana a dalaban.	5.505	
	CRCI =	CTB X R					0.055	•
	CO&M =	O&M OR CTB*25/22	/ENYR				0.0	
	COMMENTS	annon ay magazinin mata ya ki da uganasanan ya magazinin da kan		a and the area to the second of the second 			talaning a mendengan nya mpandamanan kanganya salah adapat a salah salah salah salah salah salah salah salah s	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.3.8 SUBMULTIPLEXORS

	INPUT PARAMETERS		INP	UT COEFFICIENTS
-	생활하다는 사람이 얼마를 가게 되고 있었다.			
	T= 93000.0000 TF=	0.022000	CDCER=	0.102000
	M= 3.000000 D&M=	0.0	CDEXP=	0.879000
	CF= 1.000000 Z1=	1.000000	CICER=	0.069000
	PHI= 0.980000 Z2=	60.000000	CI EXP=	0.557000
	R= 0.010000 Z3=	60.000000		
	DF= 0.000032 Z4=	60.000000	Z5 = (0.0
	CALCULATED VALUES KG	SUM TO	1.1.3	\$, MILLIONS
	CD=CDCER X (T X DF)XX(CDEXP) X CF			0.266
	CLRM=CICER X (M)XX(CIEXP) X CF X TF			0.003
В	#RM =T / M			31000.000
.87	E = 1.0 + LOG(PHI) / LOG(2.0)			0.971
				0.9/1
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.	5XX(E))		66.119
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E	1 0 EVV/F11		
	23 + 0.51AX(E	1 -0.500) / Z3	58.682
	CIPS=CTB*Z4/Z2			58.682
	CRCI =CTB X R		. The state of the	0.587
	CO&M = O&M OR CTB*Z5/Z2/ENYR			0.0
	COMMENTS			

				·	<u> </u>		
•	ROCKWELL SPS CR-2 REF		GURATION				
	TABLE 1.1.3.9 INSTRUMENTATION						ì
				and the second s	-		
	INPUT PARAMETERS			IN	PUT COE	FFICIENTS	
	T= 280000.000 TF=	1.000000		CDCER=		0.000100	
	M= 0.074100 D&M=	0.0		CDEXP=		1.000000	
	CF= 1.000000 Z1=	1.000000		CICER=		0.000400	
	PHI= 0.980000 Z2=	60.000000		CIEXP=		1.000000	
	R= 0.010000 Z3=	60.000000					
	DF= 1.000000 Z4=	60.000000	25 =		0.0		
			- 1				
	CALCULATED VALUES KG	SUM TO	1.1.3			\$, MILLIONS	
	CD=CDCER X (T X DF)XX(CDEXP) X CF	nage on a coppe, apparent sops of these magnetic transformations are a second				28.000	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF					0.000	
B	#RM = T / M				3	778676.00	
88							
00	E = 1.0 + LOG(PHI) / LOG(2.0)					0.971	
						74 3.00	
	CTFU=(CLRM / E)X(($\#$ RM X Z1+.5)XX(E) -0.	2XX(F))				74.192	
	· · · · · · · · · · · · · · · · · · ·						
	22) / Z3		45 044	
	CTB = $((CLRM/E)X((\#RM X Z3 + 0.5)XX(E$) -0.5XX(E))		1 / 23		65.846	
	C10C-CT D#7//12	And the state of t				65.846	
	CIPS=CTB*Z4/Z2					07.040	
	· CRCI =CTB X R					0.658	
	THE CHUI TO A R. S.					U • U J 0	
	COEM = DEM OR CTB*Z5/Z2/ENYR					0.0	
	CUGH - UGH UK CIDTES/LENIK					U. U	
		<u>to et la </u>					

COMMENTS

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.3.10 GPTICAL FIBER

		INPUT PARAMETERS			er en	IN	PUT COE	EFFICIENTS	n maning 2 m and maning 1
	T= M= CF= PH[=	62.00000 62.00000 1.00000 0.98000	TF= 0&M= Z1= Z2=	1.000000 0.0 1.00000 60.00000		CDCER= CDEXP= CICER= CIEXP=		0.237000 0.297000 0.010219 1.000000	
	R= DF=	0.010000 1.000000	Z3= Z4=	60.000000	Z5 =		0.0		
		ED VALUES X DF)XX(CDEXP	KG) X CF	SUM TO	1.1.3		o man makan roman makan supersupersupek sawa	\$, MILL IONS 0.807	
	CLRM=CICER X	(M)XX(CIEXP) X	CF X TF					0.634	
B-89	#RM = T / M E = 1.0 + L0)G(PHI) / LOG(2	.0)					1.000 0.971	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))						artemus is a second	0.634	
	CTB = ((CLRM/E)X((#RM X Z	3 + 0.5)XX(8	E) -0.5XX(E))) / Z3		0.578	
	CIPS=CTB*Z4/Z2 CRCI =CTB X R							0.578 0.006	er i vassa de rivera e sir i u
	COEM = OE	M OR CTB*Z5/Z2	/ENYR					0.0	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.3.11 CABLES/HARNESS

		INPUT P	ARAMETERS			INPUT CO	DEFFICIENTS	The state of the second state of the second
	- 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	293000.000	TF=	1.000000		CDCER=	0.237000	
	γ =	293000.000	=M3O	0.0	(CDEXP=	0.297000	
	CF≐	1.000000.	Z1 =	1.000000		CICER=	0.00060	
	PHI=	0.980000	Z 2=	60.000000	(CIEXP=	1.000000	الماسعين المستوان المستوانية والمستعود الإراد
	R=	0.010000	Z3=	60.000000				
	DF=	1.000000	Z 4=	60.000000	Z5 =	0.0		
	CALCUL	ATED VALUES	KG	SUM TO 1	.1.3		\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF				9.963	
	CLRM=CICER	X (M)XX(CIEXP)	CF X TF				17.580	
в-90	#RM =T / M						1.000	
90	E =1.0 + LOG(PHI) / LOG(2.0)						0.971	
	CTFU=(CLRM	/ E)X((#RM X Z1+		17.604				
	CTB =((CLRM	1/E)X((#RM X Z	3 + 0.5) XX(E) -0.5XX(E))) / Z3	16.047	
	CIPS=CTB*Z4	1/72		r en grand de la companya de la com La companya de la co	المراج في مستوالية المراج ا المراج المراج		16.047	
	CRCI =	CTB X R					0.160	
	C0&M =	0&M OR CTB*Z5/Z2	!/ENYR				0.0	
	COMMENTS							
		n de la companya de La companya de la co	ing di Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kala Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran Kalandaran					

1.1.4 ATTITUDE CONTROL AND STATIONKEEPING

This element includes the components required to orient and maintain the satellite's position and attitude in geosynchronous orbit. Included are sensors, reaction wheels, chemical and electric propulsion hardware and propellants.

The baseline ACSS features an argon ion bombardment thruster RCS whose characteristics are:

- · Thrusters located in 4 modules at each corner of the satellite
- · Each module has 16 thrusters
- Cryogenic propellant storage-electric refrigeration with heat loss makeup
- Hemispherical plume characteristics
- · Serviceable in place

The system operates on an average of 36 thrusters. A total of 64 thrusters are included to provide the required redundancy. The redundancy was based on an annual maintenance/servicing interval, 5000 hour thruster grid lifetime and 5-year thruster MTBF. Sixteen thrusters are located on the lower portion of each corner of the spacecraft. Each thruster is gimbaled individually to facilitate thruster servicing, to permit operation of adjacent thrusters during servicing, and to provide the redundancy. The thrusters nominally provide a force approximately in the direction of the sun to counter the solar pressure force (stationkeeping) which is the dominant thruster requirement. The thrusters are gimbaled through small angles (as illustrated) and differentially throttled to provide the remaining forces and torques for attitude control and stationkeeping.

Sensors that make up the attitude reference determination system include:

- CDD Sun Sensor (1/System)
- CCD Star Sensors (2/Systems)
- Electrostatic or laser gyros (3/System)
- Dedicated mini processor

The attitude reference determination system features Charge Coupled Device (CCD), star and sun sensors as well as electrostatic or laser gyros and dedicated microprocessors. Seven attitude reference determination units are located at various locations on the satellite in order to sense thermal and dynamic body bending, and to desensitize the system to these disturbances. The control algorithms will feature statistical estimators for determining principal axis orientation, body bending state observers or estimators, and a quasi-linear propulsion thrust command policy to provide precise control and minimize structural bending excitation.

The mass properties of the ACSS are summarized in Table 1.1-4. This summary includes the mass of individual elements and propellant weight on an annual basis.

Table 1.1-4. ACSS Mass Summary

TEM	MASS (x 10 ⁺³ KG)
ATTITUDE REFERENCE DETERMINATION SYSTEMS (7)	0, 32
THRUSTERS—INCLUDING SUPPORT STRUCTURE, 64 @ 120 KG/THRUSTER	7.68
THRUSTER GIMBALS AND MOUNTING	3, 98
TANKS, LINES, REFRIGERATION	15.07
POWER PROCESSING EQUIPMENT	88, 95
TOTAL (DRY)	116,00
ARGON PROPELLANT—ANNUAL REQUIREMENT	85.39
TOTAL (WITH PROPELLANT)	201, 39

Historical cost data were obtained from NASA's Redstar Data Base. Historical data relative to electrical propulsion is limited, consequently, study data have been utilized where necessary. Ion bombardment thrusters are Argon propellants with a low thrust but a significantly higher specific impulse, thus reducing propellant resupply cost.

Development of the propulsion subsystem CER's was based on the spacecraft programs listed below:

SEPS (Boeing) Study SEPS (Rockwell) Study SERT-II ATS-F (Ion Experiment) Rockwell SPS Study SERT-C Study

Range of Data:

DDT&E and ICI: 18.0 to 107,500.0 kg

Input parameters T&M are in kilograms.

Tables 1.1.4.1 and 1.1.4.2 contain the costs for this element.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.4.1 ACSS HARDWARE

· ·		INPUT P	ARAMETERS			IN	PUT COEF	FICIENTS		-
		116000.000	TF=	0.105900		CDCER=		1.122000		
	M=	1812.00000	=M30	0.046620		CDEXP=		0.190000	- AL	
	CF=	1.000000	Z 1 =	1.000000		CICER=		0.057000		
	PHI=	0.950000	Z2=	60.000000		CIEXP=		0.729000		
	R =	0.010000	Z 3 =	60.000000			1			
	DF=	0.300000	Z 4=	60.000000	Z 5 =		0.0			
	CALCUI	ATED VALUES	KG	SUM TO	1.1.4			\$,MILLI	ONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF					8.183		
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					1.432		V programme in
Б.	#RM =T / M						<u> </u>	64.018		
93	E =1.0 + LOG(PHI) / LOG(2.0)					0.926				
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				72.488		
	CTB = ((CLR)	1/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3		53.746		
	CIPS=CTB*Z	4/Z2					**************************************	53.746		*
	CRCI =	CTB X R						0.537		
	CCEM =	O&M OR CTB*Z5/Z2	/ENYR					0.047		
	COMMENTS									ine nga tanan

1			ROCKW	LL SPS	CR-2 REFE	RENCE CON	FIGURATION
TΔA	1 =	1.1.	4.2	ACSS P	ROPFILANT		

	INPUT P	ARAMETERS			IP	PUT COEFF	ICIENTS	
	1.000000	TF=	1.000000		CDCER=		0.0	
M=	1.000000	=M30	0.085390		CDEXP=		0.0	
C F=	1.000000	Z 1 =	1.000000		CICER=		0.0	
PH I≡	1.000000	72=	60.000000		CIEXP=		0.0	
R= DF=	0.0 1.000000	Z3= Z4=	60.000000 60.000000	25 =		0.0		
CALCULAT	ED VALUES		SUM TO	1.1.4			\$, MILLIONS	
CD=CDCER X (T	X DF)XX(CDEXP) X CF				0.0	·	
CLRM=CICER X	(M)XX(CIEXP) X	CF X TF					0.0	
#RM =T / M							1.000	· ·
E =1.0 + L0	G(PHI) / LOG(2	.0)					1.000	
CTFU=(CLRM /	E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))				0.0	
CTB = ((CLRM/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		0.0	
CIPS=CTB*Z4/Z	2						0.0	omena e periodo de la compansa de la
CRCI =CT	B X R				 		0.0	
	and the second of the second o							

1.1.5 COMMUNICATIONS

This element includes the hardware to transmit and receive intelligence among the various SPS elements. It includes communication of both data and voice between the SPS and the control center, as well as among the various cargo and personnel vehicles. Excluded is intravehicular and intrasatellite communications.

1.1.6 INTERFACE (ENERGY CONVERSION/POWER TRANSMISSION)

This element provides the movable interface between the energy conversion subsystem and the power transmission subsystem. A 360° rotary joint and an antenna elevation mechanism are required to maintain proper alignment of the transmitter with the ground receiving station. Included are structure, mechanisms, power distribution, and maintenance hardware.

The interface is utilized to 1) transfer energy from the slip ring to the antenna via transmission brushes, and 2) act as the structural support member between the main satellite and the antenna. The elements of this movable interface (Figure 1.1-6) are described in the following subsections.

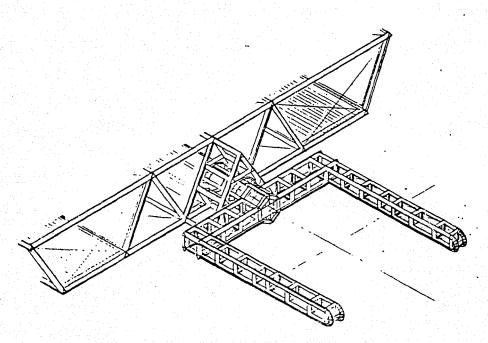


Figure 1.1-6. Energy Conversion/Power Transmission Interface

1.1.6.1 STRUCTURE

This element includes all members necessary to provide a mechanical interface between the primary structures of the energy conversion subsystem and the power transmission subsystem. It includes beams, beam couplers, cables, tensioning devices, and secondary structures. Excluded are elements of the drive assembly which are included in mechanisms (WBS No. 1.1.6.2).

1.1.6.1.1 Primary Structure

The basic supporting structure of the movable interface is included in this element. It is the primary load carrying structure and does not include the secondary structure that is required to support transmission buses or equipment.

The SPS requirement for low thermal distortion, under high thermal stress, dictates the need for a material with a very low coefficient of expansion. The most likely candidate, at this time, is a graphite composite material.

The interface primary structure D&D CER was developed using graphite composite data obtained from NASA's Redstar Data Base. Tooling cost was excluded under the assumption that this cost would be incurred in the development of orbital fabrication equipment. The following data points were used:

- Space Telescope Shell
- ATS-F Truss
- HEAO Optical Bench
- Shuttle Payload Bay Doors.

The interface structure ICI is the cost of raw materials only since the costs associated with fabrication and assembly are charged against orbital assembly and support equipment. The structure ICI cost equation is based on raw composite material stock (prepregnated graphite) cost. These material costs are based on vendor quotes obtained from Hercules, Fiberrite and Union Carbide.

Range of Data:

D&D: 30.0 to 2000.0 kg

ICI: Unlimited

1.1.6.1.2 Secondary Structure

The secondary structure consists of the passive interface attachment between the primary structure and operational subsystems. The structural members are made of aluminum with the ability to articulate, rotate, or otherwise support/allow motion between the primary structure and other subsystem elements.

This element includes all structure, consisting of mounting brackets, clamps and installation structure required as an interface and mounting attach

points of components, assemblies, and subsystems. It also includes any structure required between two or more components or assemblies.

Development of the secondary structure CER for DDT&E was based on cost data contained in the MSFC Redstar Data Base. Data from a variety of launch vehicle and unmanned satellite programs were available and the applicable data points are listed below:

- S-IVB Interstage
- S-IC Forward Skirt
- S-IC Intertank
- Solar Telescope Housing Assembly (ASM)
- Common Mount Assembly (ASM)
- Telescope Gimbal Assembly (ASM)
- Common Mount Actuators (ASM)
- Telescope Gimbal Actuators (ASM)
- Array Platform Elevation Pointing Actuator (ASM)
- UV Gimbal Mount Actuators (ASM)
- UV Instrument Mount Assembly (ASM)

- Solar Array and Boom Structure (ATS-F)
- Squib Interface Unit (ATS-F)
- Interstage (Centaur)
- Nose Shroud (Centaur)
- Fixed Airlock Shroud (Skylab)
- Payload Shroud (Skylab)
- Pallet Segment (Spacelab)
- OSO-1
- ATS-F
- S-II

The ICI production cost CER was based upon an Engineering Cost estimate.

Range of Data:

DDT&E: 6.0 to 15,000.0 kg ICI: 6.0 to 15,000.0 kg

Input parameters T&M are in kilograms of mass.

1.1.6.1.3 Cost Estimates

Primary and secondary structure costs are presented in Table 1.1.6.1.1 and 1.1.6.1.2 respectively.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.6.1.1 PRIMARY STRUCTURE

- anti-communication of the control of	INPU ¹	PARAMETERS			INPUT CO	EFFICIENTS	
	T= 120000.000 M= 20000.0000 CF= 1.000000 PHI= 1.000000		1.000000 0.0 1.000000 60.000000	CDCE CDEX CICE CIEX	P = R =	0.023000 0.800000 0.000050 1.000000	
	R= 0.002000 DF= 0.020000	23= 24=	60.000000 60.000000	Z5 =	0.0		
	CALCULATED VALUES CD=CDCER X (T X DF)XX(CDE	KG XP) X CF	SUM TO 1.1	.6.1		\$,MILLIONS 11.638	
-	CLRM=CICER X (M)XX(CIEXP)	X CF X TF				1.000	
в-99	#RM =T / M E =1.0 + LOG(PHI) / LOG	(2.0)				6.000 1.000	
	CTFU=(CLRM / E)X((#RM X Z	1+.5)XX(E) -0).5XX(E))			6.000	
	CTB = ((CLRM/E)X((#RM X	Z3 + 0.5)XX(E) -0.5XX(E))	1 /	23	6.000	
	CIPS=CTB*Z4/Z2 CRCI =CTB X R					6.000 0.012	
	CC&M = O&M OR CTB*Z5/	ZZ/ENYR				0.0	
	COMMENS						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.6.1.2 SECONDARY STRUCTURE

		INPUT P	ARAMETERS	The second secon		INPUT C	OEFFICIENTS		
	Τ=	365000.000	TF=	0.007300		CDCER=	0.156000		
	M=	5.000000	=M30	0.0		CDEXP=	0.511000		
	CF=	1.000000	Z1=	1.000000		CICER=	0.101000		
	PHI=	0.980000	Z2=	60.000000		CIEXP=	0.355000		
	R=	0.002000	Z3=	60.000000		Construction of the contract o	မှာသော ရှိသိသည် သားသေးမှုသည်သည် လူသည်သည် သည်သည် သည်သည် သည်သည် သည်သည် သည်သည် သည်သည်။ သည်သည်		
	DF=	0.050000	Z 4=	60.000000	Z5 =	0.0			
	CALCUI	LATED VALUES	KG	SUM TO 1.	1.6.1		\$, MILLIONS		
	CD=CDCER X (T X DF)XX(CDEXP) X CF						23.476		
			· Andrew State (er e maner parte e maner e maner e maner. Artista e la companya de la companya			
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				0.001		
벼	#RM =T / M				·		73000.000		
100	E =1.0 + LOG(PHI) / LOG(2.0)						0.971		
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			70.827		
Newscontains - The special	CTB = ((CLR)	M/E)X((#RM X Z	3 + 0.5)XX	E) -0.5XX(E))) / Z3	62.860		
W.e.	CIPS=CTB*Z4/Z2						62.860		
	CRCI =CTB X R					de de la la manda de la manda	0.126		
	CO&M =	O&M OR CTB*Z5/Z2	/ENYR			0.0			
	COMMENTS								

1.1.6.2 MECHANISMS

This element includes the components required to rotate and elevate the power transmission subsystem. Included are the drive ring, bearings, gear drives, and drive motors.

The structural mechanisms consist of active structural subassemblies that articulate, rotate, or otherwise cause or allow motion between the primary structure and other subsystem elements or between subsystem elements themselves.

The ICI production cost CER was based on data provided by the following manufacturers:

Manufacturer	Application		
Poly-Scientific	High energy		
Poly-Scientific .	Radar		
Electro-Tec	Navy destroyer	propeller	system

Electro-Tec Satellite solar array

I.E.C. Navy shipboard hoist

Due to the difference in complexity and the specification requirements differences between ground and space qualified equipment, the following factors were applied.

Complexity Fac	ctor		×	3
Specification	Uprating	Factor	×	3
Total			×	9

Range of Data:

DDT&E: 6.0 to 15,000.0 kg ICI: 6.0 to 15,000.0 kg

Input parameters T&M are in kilograms of mass, see Table 1.1.6.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.6.2 MECHANISMS - INTERFACE

INPUT PARA	METERS		INPUT CO	EFFICIENTS	with superior
T= 391000.000	TF= 0.054900		CDCER=	0.156000	
	0.078000		CDEXP=	0.511000	
	Z1= 1.000000		CICER=	0.000764	
	Z 2= 60.000000		CIEXP=	0.950000	
	Z3= 60.000000 Z4= 60.000000		0.0		
CALCULATED VALUES	KG SUM TO	1.1.6		\$, MILLIONS	6
CD=CDCER X (T X DF)XX(CDEXP) X	C.CF	and the second s	en e	15.225	
CLRM=CICER X (M)XX(CIEXP) X CF	X TF			0.012	
₩ #RM =T / M				1000.000	
#RM =T / M H C E =1.0 + LOG(PHI) / LOG(2.0)		a principal description of a gasterial part of the second	ميدانده توشد داد د دريون ميد مجموع داد را باست. او دريوا را اداد	0.926	
CTFU=(CLRM / E)X((#RM X Z1+.5)	XX(E) -0.5XX(E))			7.878	
CTB = ((CLRM/E)X((#RM X Z3 +	- 0.5)XX(E) -0.5XX(E))) / 23	5.821	
CIPS=CTB*Z4/Z2			Albanian da	5.821	
CRCI = CTB X R				0.058	
CO&M = O&M OR CTB*Z5/Z2/EN	eti eraku di kacamatan di kabilan di I YR a dengah di kacamatan di kepada di kabilan			0.078	
COMMENTS					

1.1.6.3 POWER DISTRIBUTION

This element transmits the electrical power from the rotary joint to the microwave power transmission system. The PD&C system consists of power risers which are coupled to the pickup shoebrushes on the rotary joint and routed on the antenna support yolk (interface) to the isolation switches on the antenna proper. There are two sets of slip rings. One positive and one negative, at the rotary joint. Sixteen brushes are needed per slip ring. The life expectancy of the PD&C is 30 years with calculated replacements of the slip ring.

1.1.6.3.1 Conductors and Insulation.

The power risers are sized to minimize the mass of itself and the satellite mass, considering power requirements, efficiency and variation in resistivity with operating temperature. The power risers are made of multiple round aluminum (6101-T6) conductors with 1 mm kapton insulation.

1.1.6.3.2 Pickup Shoe Brushes

The pickup shoe brush portion of the rotary joint is included in the power distribution of the interface segment. Sixty-four pickup shoe brush assemblies are required per satellite. The brush material is 75% M₀S₂ and 25% M₀tTa with a contact surface area per brush of 863 cm². The shoe dimension is 2.72 m × 12.7 am × 19 am with a total weight of 11341 kg for 64 pickup shoe brushes.

1.1.6.3.3 Power Distribution Cost Estimates

The CER presented in section 1.1.1.4.2 was used for the conductors and insulation. An extension of this CER was used for the brushes of section 1.1.6.3.2. The cost estimates for interface power distribution are presented in Tables 1.1.6.3.1 and 1.1.6.3.2.

	ROCKWELL SPS CR-2	REFERENCE CONFIGURATION
TABLE 1.	1.6.3.1 CONDUCTOR &	INSULATION

	INPUT PARAMETERS		INPUT CO	EFFI CI ENTS	· · · · · · · · · · · · · · · · · · ·
	T= 1267000.00 TF=	1.000000	CDCER =	0.158000	
	M= 39594.0000 O&M=	0.0	CDEXP=	0.297000	
	CF= 1.000000 Z1=	1.000000	CICER=	0.000004	
	PHI= 1.000000 Z2=	60.000000	CIEXP=	1.000000	
	R= 0.0 Z3=	60.000000			
	DF= 0.100000 Z4=	60.000000	25= 0.0		
	CALCULATED VALUES KG	SUM TO 1.	1.6.3	\$,MILLIONS	
	CD=CDCFR X (T X DF)XX(CDEXP) X CF			5.178	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF			0.158	
Ħ	#RM =T / M			32.000	
-104	E =1.0 + LOG(PHI) / LOG(2.0)			1.000	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.	5XX(E))		5.068	
	CTB = ((CLRM/E)X1(#RM X Z3 + 0.5)XX(E) -0.5XX(E))	1 / 23	5.068	
	CIPS=CTB*Z4/Z2			5.068	
	CRCI =CTB X R			0.0	
	CEEM = DEM OR CTB*Z5/Z2/ENYR			0.0	
	COMMENTS			and a sure of the	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.6.3.2 SLIP RING BRUSHES

	INPUT PARAMETERS			INPUT COEFFICIENTS					
		11341.0000	TF=	1.000000		CDCER=		0.158000	
	M=	531.000000	=M30	0.0		CDEXP=		0.297000	
	CF=	1.000000	Z1=	1.000000		CICER=		0.000200	
.,	PH I = R =	0.950000 0.010000	Z2= Z3=	60.000000		CIEXP=		1.000000	an de la constanta de la companya de
	R= DF=	0.010000 0.020000	Z4=	60.000000	75 =		0.0		
		0.02000	2.17						
	CALCUL	ATED VALUES	KG	SUM TO	1.1.6.3			\$, MILL IONS	
	CD=CDCER X	(T X DF)XX(CDEX) X CF		najana san kanasa salah sesi		ا الماريخ الماريخ الماري	0.791	
	CLRM=CICER	X (M)XX(CIEXP)	CF X TF					0.106	
· .								21.358	
₽ .I	#RM =T / M							21.336	
105	E = 1.0 +	LOG(PHI) / LOG(2	2.0)					0,926	er ann ann gan aide ann a' deireadhachta each a
	CTFU=(CLRM	/ E)X((#RM X Z1+	⊦.5)XX(E) -0.	.5XX(E))				1.935	
				<u>-</u>					·
	CTB = (CLRM	/E)X((#RM X 2	23 + 0.5)XX(E	-0.5XX(E))) / Z3		1.442	
· · · · · · · · · · · · · · · · · · ·	CIPS=CTB*Z4	/72					المنافية المنافية المنافقة المنافقة	1.442	
	CRCI =	CTB X R						0.014	
	COEM =	O&M OR CTB*Z5/Z2	2/ENYR					0.0	
	COMMENTS			a di kacampang kangalang di didikat Pangalang di didikat d					
		 The first of the second of the							

1.1.6.4 THERMAL CONTROL

This element includes any component used to modify the temperature of interface subsystem components. It includes cold plates, heat transfer and radiator devices as well as insulation, thermal control coatings and finishes. Excluded are paints or finishes applied to components during their manufacturing sequence. No thermal control requirements are defined for the interface.

1.1.6.5 MAINTENANCE

This element provides for in-place repair or replacement of components and includes work stations, tracks, access ways, and insitu repair equipment.

Maintenance requirements are related to the equipment and facilities needed to transport men and material to the work station. Some of the same equipment required for maintenance at the site is used commonly in the performance of work at other sites. The CER's accommodate this usage. Table 1.1.6.5 identifies the requirements, and cost estimates are provided in Tables 1.1.6.5.1, 1.1.6.5.2, and 1.1.6.5.3.

Table 1.1.6.5 Maintenance Requirements

WBS NO.	MAINTENANCE ITEM DESCRIPTION	1.1.6.5 INTERFACE
1.1.6.5.1	"FREE-FLYERS" OR BARGE FOR CARGO AND PERSONNEL (COMMON USE ITEM)	.2 VEHICLE UTILIZATION
1.1.6.5.2	MANNED MANIPULATOR MODULE	1 VEHICLE
1.1.6.5.3	TRACKS AND ACCESS WAYS	24000 kg

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.1.6.5.1 MAINTENANCE - FREE FLYERS

T= 5000.00000 TF= 1.000000 CDCER= 0.0 M= 5000.00000 D&M 0.0 CF= 1.250000 Z1= 0.200000 CICER= 0.005798 PHI= 0.950000 Z2= 60.000000 CIEXP= 1.000000 R= 0.020000 Z3= 12.000000 DF= 1.000000 Z4= 12.000000 Z5= 0.0 CALCULATED VALUES KG SUM TO 1.1.6.5 \$.MILLIONS CD=CDCER X (T X DF)XX(CDEXP) X CF 0.0 CLRM=CICER X (M)XXX(CIEXP) X CF X TF 36.238 #RM = T / M 1.000 E =1.0 + LOG(PHI) / LOG(2.0) 0.926 CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) 7.530 CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 32.098 CIPS=CTB*Z4/Z2 6.420 CRCI = CTB X R 0.642 CO&M = D&M OR CTB*Z5/Z2/ENYR 0.0	INPUT PARAMETERS		INPUT C	DEFFICIENTS
CF= 1.250000 Z1= 0.200000 CICER= 0.005798 PHI= 0.950000 Z2= 60.000000 CIEXP= 1.000000 PHI= 0.950000 Z3= 12.000000 Z5= 0.0 CIEXP= 0.0 CIEXP= 1.000000 Z5= 1.000000 Z4= 12.000000 Z5= 0.0 CIEXP= 0.0 CALCULATED VALUES KG SUM TO 1.1.6.5 \$,MILLIONS CD=CDCER X (T X DF)XX(CDEXP) X CF Q.0 CLRM=CICER X (M)XX(CIEXP) X CF ZF Z5	T= 5000.00000 TF=	1.000000	CDC ER =	0.0
PHI= 0.950000 Z2= 60.000000 CIEXP= 1.000000 R= 0.020000 Z3= 12.000000 DF= 1.000000 Z4= 12.000000 Z5= 0.0 CALCULATED VALUES KG SUM TO 1.1.6.5 \$,MILLIONS CD=CDCER X (T X DF)XX(CDEXP) X CF 0.0 CLRM=CICER X (M)XX(CIEXP) X CF X TF 36.238 #RM =T / M 1.000 E =1.0 + LOG(PHI) / LOG(2.0) 0.926 CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) 7.530 CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 32.098 CIPS=CTB*Z4/Z2 6.420 CRCI =CTB X R 0.642				
R= 0.020000				
DF= 1.000000 Z4= 12.000000 Z5= 0.0 CALCULATED VALUES KG SUM TO 1.1.6.5 \$.MILLIONS CD=CDCER X (T X DF)XX(CDEXP) X CF 0.0 CLRM=CICER X (M)XX(CIEXP) X CF X TF 36.238 #RM = T / M 1.000 E =1.0 + LOG(PHI) / LOG(2.0) 0.926 CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) 7.530 CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 32.098 C1PS=CTB*Z4/Z2 6.420 CRCI =CTB X R 0.642	AND THE REPORT OF THE PARTY OF		CIEXP=	1.000000
CALCULATED VALUES KG SUM TO 1.1.6.5 \$,MILLIONS CD=CDCER X (T X DF)XX(CDEXP) X CF 0.0 CLRM=CICER X (M)XX(CIEXP) X CF X TF 36.238 #RM = T / M 1.000 E = 1.0 + LOG(PHI) / LOG(2.0) 0.926 CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) 7.530 CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 32.098 CIPS=CTB*Z4/Z2 6.420 CRCI = CTB X R 0.642	그렇게 하는 생생님, 그 그 사람들은 사람들이 살아 가는 그 때문에 가장 그 때문에 가장 그를 가장 하는데 되었다.		0.0	
CD=CDCER X (T X DF)XX(CDEXP) X CF CLRM=CICER X (M)XX(CIEXP) X CF X TF 36.238 #RM = T / M 1.000 E = 1.0 + LOG(PHI) / LOG(2.0) CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) 7.530 CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 32.098 CIPS=CTB*Z4/Z2 CRCI =CTB X R 0.642	UF= 1.000000 Z4=	12.000000 25=	0.0	
CLRM=CICER X (M)XX(CIEXP) X CF X TF #RM =T / M 1.000 E =1.0 + LOG(PHI) / LOG(2.0) CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) T.530 CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E)) CTB =(CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E)) CTB = CTB X R 0.642	CALCULATED VALUES KG	SUM TO 1.1.6.5		\$, MILLIONS
#RM =T / M E =1.0 + LOG(PHI) / LOG(2.0) CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 CIPS=CTB*Z4/Z2 CRCI =CTB X R 1.000 7.530 7.530 0.926 0.926 0.642	CD=CDCER X (T X DF)XX(CDEXP) X CF			0.0
E =1.0 + LOG(PHI) / LOG(2.0) 0.926 CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) 7.530 CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 32.098 CIPS=CTB*Z4/Z2 6.420 CRCI =CTB X R 0.642	CLRM=CICER X (M)XX(CIEXP) X CF X TF			36.238
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 32.098 CIPS=CTB*Z4/Z2 6.420 CRCI =CTB X R 0.642	#RM =T / M			1.000
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 32.098 CIPS=CTB*Z4/Z2 6.420 CRCI = CTB X R 0.642	E =1.0 + LOG(PHI) / LOG(2.0)			0.926
CIPS=CTB*Z4/Z2 CRCI = CTB X R 0.642	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5	XX(E))		7.530
CRCI = CTB X R	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E)	-0.5XX(E))) / Z3	32.098
	CIPS=CTB*Z4/Z2			6.420
CO&M = O&M OR CTB*Z5/Z2/ENYR	CRCI = CTB X R			0.642
	CO&M = O&M OR CTB*Z5/Z2/ENYR			0.0
COMMENTS:	COMPANIO CONTRACTOR CO			

	ROCKWELL SPS	CR-2 REFERENCE	CONFIGURATION
TABLE 1.1	.6.5.2 MANNED	MANIPULATOR	
그 이번 등을 들었다면 뭐는데 [117]			

	INPUT P	ARAMETERS			INPUT C	DEFFICIENTS	
	3000.00000	TF=	1.000000		CDCER=	0.0	
M= 148	3000.00000	=M30	0.0		CDEXP=	0.0	
CF=	1.100000	Z 1=	1.000000		CICER=	0.005798	
PHI=	0.950000	Z2=	60.000000		CIEXP=	1.000000	
R=	0.020000	7.3=	60.000000				
D.F =	1.000000	74=	60.000000	Z5 =	0.0		
CALCUL	ATED VALUES	KG	SUM TO 1	.1.6.5		\$,MILLIONS	
CD=CDCER X	(T X DF)XX(CDEXP) X CF				0.0	- 1
CLRM=CICER X	X (M)XX(CIEXP) X	CF X TF				19.133	
#RM =T / M B E =1.0 + I						1.000	
E = 1.0 + 1	LOG(PHI) / LOG(2	.0)				0.926	
CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			19.203	
CTB = ((CLRM)	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))		1 / 23	15.198	
CIPS = CTB*Z4	/22			المتعلقة في المتعلقية المتعلقة في المتعلقة		15.198	ar in in had all in her in
CRCI =	CTB X R					0.304	
COSM = (DEM OR CTB*Z5/Z2	/ENYR				0.0	
COMMENTS	ang kabupatèn kabupatèn di Kabupatèn Balangan Kabupatèn Kabupatèn Balangan						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.6.5.3 TRACKS & ACCESS WAYS

The second second		INPUT PARAMETERS		and the second contract of the second contrac	INPUT COEFFICIENTS				
		24000.0000	TF=	1.000000		CDC ER =		0.0	
	M=	24000.0000	=M3O	0.0		CDEXP=		0.0	
	CF=	1.000000	Z1=	1.000000		CICER=		0.000005	
	PHI=	1.000000	Z 2=	60.000000		CIEXP=		1.00000	
	R=	0.002000	Z3=	60.000000					
	DF=	1.000000	Z 4=	60.000000	25 =		0.0		
	CALCUL	ATED VALUES	KG	SUM TO	1.1.6.5			\$,MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXE	Y) X CF					0.0	
	CLRM=CICER	X (M)XX(CIEXP)	CF X TF					0.120	
В	#RM =T / M							1.000	
110	E = 1.0 +	LOG(PHI) / LOG(2	2.0)					1.000	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))							0.120	
	CTB = ((CLRM	/E)X((#RM X 2	3 + 0.5)XX(E) -0.5XX(E))) / Z3		0.120	
	CIPS=CTB*Z4	/12			e conser de dans de la companya de l	er en same de la company de	and the second s	0.120	
	CRCI =	CTB X R						0.000	
	= M303	O&M OR CTB*Z5/Z2	!/ENYR					0.0	
	COMMENTS								

1.1.7 SYSTEMS TEST

This element includes the hardware, software, and activities required for ground-based systems test including qualification tests and other development tests involving two or more subsystems or assemblies. It includes the production, assembly, integration, and checkout of satellite system hardware into a full or partial system test article. It also includes the design, development, and manufacture of special test equipment, test fixtures, and test facilities that are not included in other elements such as ground support facilities. Also included are the planning, documentation, and actual test operations.

Tables 1.1.7.1 and 1.1.7.2 document DDT&E cost estimates respectively for hardware and operations based on individual calculations equal to 50% of the satellite ICI.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.7.1 SYSTEM GROUND TEST HARDWARE

	TABLE 1.1.7.1 SYSTEM GROUND TEST HARDWARE	
****	INPUT PARAMETERS	PUT COEFFICIENTS
<u> </u>	T= 0.0 TF= 1.000000 CDCER= M= 0.0 D&M= 0.0 CDEXP=	0.0
· · · · · · · · · · · · · · · · · · ·	CF= 0.0 Z1= 1.000000 CICER= PHI= 1.000000 Z2= 60.000000 CIEXP= R= 0.0 Z3= 60.000000	0 • 0 0 • 0
	DF= 1.000000 Z4= 60.000000 Z5=	0.0
	CALCULATED VALUES SET SUM TO 1.1.7	\$, MILLIONS
	CD=CDCER X (T X DF)XX(CDEXP) X CF	2662.711
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.0
ਸ •	#RM = T / M	0.0
112	E = 1.0 + LOG(PHI) / LOG(2.0)	0.0
·	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	0.0
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	0_{ullet}
	CIPS=CTB*Z4/Z2	0.0
	CRCI = CTB X R	0.0
	CORM = ORM OR CTB*Z5/Z2/ENYR	0.0
	COMMENTS DCT&E = 50% OF SATELLITE ICI	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.7.2 SYSTEM GROUND TEST OPERATIONS

	INPUT PARAMETERS	The state of the s	INPUT	COEFFICIENTS	The second secon
	0.0 TF=	1.000000	CDCER=	0.0	
M= C F= PH [=	0.0 O&M= 0.0 Z1= 1.000000 Z2=	0.0 1.000000 60.000000	CDEXP= CICER= CIEXP=	0.0 0.0 0.0	
R= DF=	0.0 Z3= 1.000000 Z4=	60.000000	Z5 = 0.0	e magneting a garage and garage and a series of the property of the series of the ser	
CALCULA	TED VALUES SET	SUM TO 1.1	.7	\$, MILLION	S
CD=CDCER X (T X DF)XX(CDEXP) X CF			2662.711	
CLRM=CICER X	(M)XX(CIEXP) X CF X TF			0.0	
#RM =T / M	DG(PHI) / LOG(2.0)			0.0	
CTFU=(CLRM /	E)X((#RM X Z1+.5)XX(E) -	-0.5XX(E)}		0.0	
CTB = ((CLRM/	E)X((#RM X Z3 + 0.5)X)	((E) -0.5XX(E))) / Z3	0.0	
CIPS=CTB*Z4/	Σ2	a la company de la company		0.0	
CRCI =C	TB X R			0.0	
O = M303	EM OR CTB*Z5/Z2/ENYR			0.0	
COMMENTS DDT&E TE	ST OPS = 50% OF SATELLITE	ici - Ici			

1.1.8 GROUND SUPPORT EQUIPMENT (GSE)

This element includes all ground-based hardware required in support of handling, servicing, test, and checkout of the satellite subsystems. It also includes special hardware required for simulations and training.

Costs for design, development, manufacture, acceptance, qualification, and maintenance of the GSE equipment are included. It is recognized that various equipments can serve multipurposes. For example, a developmental mockup may later serve as a training aid after it has served its original purposes. In these instances, the acquisition cost is charged to the original or first purpose use, and subsequent usage will incur only the recurring operations and maintenance costs.

GSE costs from several launch vehicle, manned spacecraft and unmanned satellites were analyzed to determine their applicability to SPS GSE requirements. From these data, a percentage factor was developed which was used to estimate SPS ground support equipment costs. This factor is expressed by the equation CD = 0.10 (C); where C = DDT&E cost of the satellite system. See Table 1.1.8.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.8 GROUND SUPPORT EQUIPMENT

رية يستسب	INPUT PARAMETERS	INPUT CO	The state of the s	
	T= 0.0 TF= 1.000000 M= 0.0 0EM= 0.0 CF= 0.0 Z1= 1.000000	CDC FR = CDEXP = CICER =	0.0 0.0 0.0	
	PHI= 1.000000 Z2= 60.000000 R= 0.0 Z3= 60.000000	CIEXP=	0.0	en e
	DF= 1.000000 Z4= 60.000000	Z5 = 0 • 0		
	CALCULATED VALUES SET SUM TO 1		\$, MILLIONS	
	CD=CDCER X (T X DF)XX(CDEXP) X CF	and the second seco	721.234	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF		0.0	
В	#RM = T / M		0.0	
5	E = 1.0 + LOG(PHI) / LOG(2.0)		0.0	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))		0.0	
	CTB = $((CLRM/E)X((\#RM X Z3 + 0.5)XX(E) -0.5XX(E))$) / Z3	0.0	
	CIPS=CTB*Z4/Z2		0.0	
	CRCI = CTB X R	and the second s	0.0	
	CC&M = O&M OR CTB*Z5/Z2/ENYR		0.0	
	COMMENTS DDT&E GSE = 10% OF SATELLITE DDT&E ABOVE			

1.1.9 PRECURSOR TEST ARTICLE

(,

The 335 MW pilot plant precursor test article and operations is included in this element. It represents the technology verification space system combining the energy conversion, interface, and power transmission segments of the SPS satellite. The configuration will be constructed by the satellite construction base where the sequence is to build the slip ring/rotary joint housing structure followed by the interface hub and yoke base plus the 1st bay of the solar array. Slip rings are installed and the solar concerter portion is completed as the yoke (interface) arms are fabricated. The antenna construction and maintenance platform is attached to provide facilities for the antenna fabrication and installation of required power modules. The completed EOTV/Demo unit is illustrated in Figure 1.1.9.

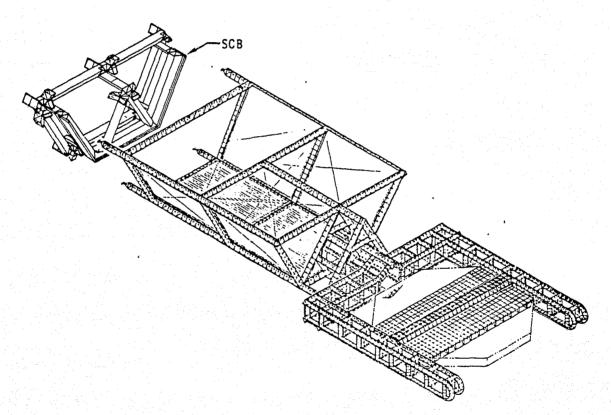


Figure 1.1.9 EOTV Precursor Test Article

1.1.9.1 EOTV PRECURSOR VEHICLE

Tables

This element covers the vehicle procurement required to support the integrated test and demonstration program.

The energy conversion segment of the vehicle consists of primary and secondary structure, concentrators, solar blankets, switchgear and converters, conductors/insulation, attitude control and information management subsystems. The interface segment includes the primary and secondary structure, mechanisms, conductors/insulation and slip ring brushes.

The precursor power transmission segment will be representative of the full-up satellite antenna to the extent of using identically available components for the required power levels of the test article. It will include structures, transmitter subarrays, power distribution and conditioning, batteries, insulation, and phase control elements.

CER's used in this section are the same as those used in the particular elements of earlier satellite sections. DDT&E is, however, a main cost item in these categories as the systems/subsystems will require substantial development activities, whereas the other satellite systems/subsystems will capitalize from this development work.

Cost estimates for the precursor test article are presented in the following tables:

Tables	Segment		
1.1.9.1.1 thru 1.1.9.1.8	Energy Conversion		
1.1.9.1.9 thru 1.1.9.1.13	Interface		
1.1.9.1.14 thru 1.1.9.1.24	Power Transmission		

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.1 PRIMARY STRUCTURE - E.C.

- 	INPUT PARAMETERS INPUT C	INPUT COEFFICIENTS			
	T= 30890.0000 TF= 1.000000 CDCER=	0.023000			
	M= 2059.00000 O&M= 0.0 CDEXP=	0.800000			
	CF= 1.000000 Z1= 1.000000 CICER=	0.000050			
	PHI= 1.000000 Z2= 60.000000 CIEXP= R= 0.0 Z3= 0.0	1.000000			
	DF =				
	CALCULATED VALUES KG SUM TO 1.1.9.1	\$, MILL IONS			
	CD=CDCER X (T X DF)XX(CDEXP) X CF	89.863			
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.103			
ᄧ	#RM =T / M	15.002			
B-118	E =1.0 + LOG(PHI) / LOG(2.0)	1.000			
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	1.544			
province and the second	CTB = $((CLRM/E)X((\#RM X Z3 + 0.5)XX(E) -0.5XX(E))$) / Z3	0.0			
	CIPS=CTB*Z4/Z2	0.0			
	CRCI =CTB X R	0.0			
	CO&M = O&M OR CTB*Z5/Z2/ENYR	0.0			
	COMMENTS				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.2 SECONDARY STRUCTURE - E.C.

	INPUT PARAMETERS			INPUT COEFFICIENTS				a jaka daga kan kan kan basa daga kan ba Kan basa daga kan basa dag	
	T= 1	4918.0000 5.000000	= TF= 0 & M=	1.000000		CDCER=		0.156000 0.511000	
	CF= PHI=	1.000000	Z 1 = Z 2 =	1.000000		CICER= CIEXP=		0.101000 0.355000	
	R= DF=	0.0 1.000000	Z 3 = Z 4=	0.0 60.000000	Z5 =	****	0.0		
	CALCULATE	D VALUES	KG	SUM TO	1.1.9.1			\$,MILLIONS	
er er gjore	CD=CDCER X (T	X DF)XX(CDEXP) X CF					21.178	
	CLRM=CICER X (M)XX(CIEXP) X	CF X TF					0.179	
В	#RM =T / M				· · · · · · · · · · · · · · · · · · ·			2983.600	
119	E = 1.0 + LOG	(PHI) / LOG(2	.0)			غوالم المعالج		1.000	and an in the second of the second
-	CTFU=(CLRM / E)X((#RM X Z1+	.5)XX(E) -0.	.5XX(E))				533.576	
-	CTB =((CLRM/E)	X (I # RM X Z	3 + 0.5)XX(E	E) -0.5XX(E))) / 23		0.0	
	CIPS=CTB*Z4/Z2				ر المنظم مطلب وأن مسيريت المستطلس المنافع المنافع المنافع المنافع المنافع المنافع المنافع المنافع المنافع المن المنافع المنافع المناف		erandare Springer V	0.0	ا دود تواد کور اندهوند داشتاند. (۱۱)
	CRCI =CTB	X R						0.0	4
	CCEM = OEM	OR CTB*Z5/Z2	/ ENYR					0.0	
	COMMENTS							gan grigor samental e disposari que en el color de la color de La color de la	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.1.9.1.3 CONCENTRATOR - E.C.

	INPUT PARAMETERS	INPUT COEFFICIENTS
	T= 1800000.00 TF= 1.000000	CDCER= 0.027000
	M= 450000.000 0&M= 0.0	CDEXP= 0.394000
	CF= 1.000000 Z1= 1.000000	CICER = 0.000003
	PHI= 1.000000 Z2= 60.000000	CIEXP= 0.950000
	R= 0.0 Z3= 0.0	
	DF= 1.000000 Z4= 60.000000 Z	0.0
	CALCULATED VALUES SQ M SUM TO 1.1.9	.1 \$,MILLIONS
	CD=CDCER X (T X DF)XX(CDEXP) X CF	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.704
~ ~~	#RM =T / M	4.000
B-120	E =1.0 + LOG(PHI) / LOG(2.0)	1.000
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	2.817
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) $-0.5XX(E)$)) / Z3 0.0
	CIPS=CTB*Z4/Z2	
· .	CRCI =CTB: X R	0.0
	COEM = OEM OR CTB*Z5/Z2/ENYR	0.0
	COMMENTS	
	소리 轉 되는 하는 사람들에 살아 가장 하는 사람들이 하늘 한 수 있는 가는 가능을 하는 것들다.	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.4 SOLAR BLANKET -E.C.

	INPUT PARAMETERS	INPUT COEFFICIENTS			
	T= 900000.000 TF= 1.000000 M= 18750.0000 0&M= 0.0 CF= 1.000000 Z1= 1.000000 PHI= 1.000000 Z2= 60.000000 R= 0.0 Z3= 0.0 DF= 2.000000 Z4= 60.000000 Z5	CDCER= 0.161400 CDEXP= 0.394000 CICER= 0.000067 CIEXP= 1.000000			
	CALCULATED VALUES KG SUM TO 1.1.9. CD=CDCER X (T X DF)XX(CDEXP) X CF	\$,MILLIONS 47.041			
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	1.256			
B-121	#RM =T / M E = 1.0 + LOG(PHI) / LOG(2.0)	48.000 1.000			
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	60.300			
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 0.0			
	CIPS=CTB*Z4/Z2 CRCI =CTB X R	0.0			
	COEM = OEM OR CTB*Z5/Z2/ENYR COMMENTS	0.0			
	- 발생성이 되는 그는 사람들이 가입되는 하는 말로 가입이 되었다. 그리고 있는 것으로 되었다. 				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.5 SWITCHGEAR & CONVERTERS -E.C.

	INPUT C	DEFFICIENTS
	T= 2875.00000 TF= 1.000000 CDCER=	0.158000
	M= 719.000000 ΘεM= 0.0 CDEXP=	0.297000
	CF= 1.500000 Z1= 1.000000 CICER=	0.000400
**************	PHI= 1.000000 Z2= 60.000000 CIEXP= R= 0.0 Z3= 0.0	1.000000
	R= 0.0 Z3= 0.0 DF= 3.000000 Z4= 60.000000 Z5= 0.0	
	CALCULATED VALUES KG SUM TO 1.1.9.1	\$, MILLIONS
	CD=CDCFR X (T X DF)XX(CDEXP) X CF	3.497
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.431
ᄧ	#RM =T / M	3.999
B-122	E =1.0 + LOG(PHI) / LOG(2.0)	1.000
	CTFU=(CLRM / E)X((#RM X ZI+.5)XX(E) -0.5XX(E))	1.725
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	0.0
	CIPS=CTB*Z4/Z2	0.0
	CRCI =CTB X R	0.0
	CORM = ORM OR CTB*Z5/Z2/ENYR	0.0
	COMMENTS	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.6 CONDUCTORS & INSULATION - E.C.

					F5.	
TNP	HIT	РΔ	RAM	FT	FR	S

INPUT COEFFICIENTS

	T= 357675.000	TF=	1.000000	CDC ER =	0.158000	
	M= 7452.00000	=M3O	0.0	CDEXP=	0.297000	
	CF= 1.000000	Z 1 =	1.00000	CICER=	0.000004	
	PHI= 1.000000	Z 2=	60.000000	CIEXP=	1.000000	
	R= 0 •0	23=	0.0			
	DF= 1.000000	Z 4=	60.000000	25 = 0.0		
	CALCULATED VALUES	KG	SUM TO 1.1.5).1	\$,MILLIONS	
					7.040	
	CD=CDCER X (T X DF)XX(CDE	XP) X CF			7.048	
		V 65 V 75			0.030	
	CLRM=CICER X (M)XX(CIEXP)	X CF X TF			0.030	
	70 N T / M				47.997	
В	#RM =T / M					
123	E =1.0 + LOG(PHI) / LOG	(2.0)			1.000	. * *
ω	E -1.0 + E00(FIII / C00	(2.0)		and the second section of the second second second second second second second second section section second secon		ilini masa maja an makin para-
	CTFU=(CLRM / E)X((#RM X Z	1+.5)XX(E) -	0.5XX(E))		1.431	
	CTB = ((CLRM/E)X((#RM X	Z3 + 0.51XX	(E) -0.5XX(E))) / Z3	0.0	
	CIPS=CTB*Z4/Z2				0.0	
	CRCI = CTB X R				0.0	
			어느 함께 학생 경험 등 시간			
	COEM = DEM OR CTB*Z5/	Z2/ENYR			0.0	
				واستناهها والمهاوا الماسين الماسي الماسي الماسي الماسي		
	COMMENTS					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.7 ACS HARDWARE - E.C.

	AND PARTY OF THE PARTY AND THE	
	INPUT PARAMETERS INPUT C	COEFFICIENTS
	T= 283557.000 TF= 0.300000 CDCER=	1.122000
	M= 1970.00000 Ω&M= 0.0 CDEXP=	0.190000
	CF= 1.000000 Z1= 1.000000 CICER= PHI= 1.000000 Z2= 60.000000 CIEXP=	0.057000
	PHI= 1.000000 Z2= 60.000000 CIEXP= R= 0.0 Z3= 0.0	0.729000
	DF= 1.000000 Z4= 60.000000 Z5= 0.0	
	CALCULATED VALUES KG SUM TO 1.1.9.1	\$, MILL IONS
	CD=CDCFR X (T X DF)XX(CDEXP) X CF	12.190
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	4.312
 Β	#RM =T / M	143.938
124	E =1.0 + LOG(PHI) / LOG(2.0)	1.000
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	620.634
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	0.0
	CIPS=CTB*Z4/Z2	0.0
· · · · · ·	CRCI =CTB X R	0.0
	CO&M = O&M OR CTB*Z5/Z2/ENYR COMMENTS	0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.8 SLIPRINGS - PRECURSOR

white and	INPUT PARAMETERS INPUT CO	DEFFICIENTS
	T= 43000.0000 TF= 1.000000 CDCER= M= 10750.0000 D&M= 0.0 CDEXP=	0.156000 0.511000
	CF= 1.500000 Z1= 1.000000 CICER= PHI= 1.000000 Z2= 60.000000 CIEXP=	0.000764 0.950000
	R= 0.0 Z3= 0.0 DF= 1.000000 Z4= 60.000000 Z5= 0.0	
	CALCULATED VALUES KG SUM TO 1.1.9.1	\$,MILLIONS
	CD=CDCER X (T X DF)XX(CDEXP) X CF	54.565
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	7.745
B-1	#RM =T / M	4.000
125	E = 1.0 + LOG(PHI) / LOG(2.0)	1.000
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	30.980
	CTB = $((CLRM/E)X((\#RM X Z3 + 0.5)XX(E) -0.5XX(E))$) / Z3	0.0
	CIPS=CTB*Z4/Z2	0.0
	CRCI =CTB X R	0.0
	CC&M = O&M OR CTB*Z5/Z2/ENYR	0.0
	COMMENTS	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.1.9.1.9 PRIMARY STRUCTURE - INTERFACE

		INPUT P	ARAMETERS			IN	PUT COE	FFICIENTS	
······	T=	120000.000 200.000000 1.000000	TF= O&M= Z1=	1.000000 0.0 1.000000		CDCER= CDEXP= CICER=		0.023000 0.800000 0.000050	
	PHI= R= DF=	1.000000 0.0 0.500000	Z 2 = Z 3 = Z 4 =	60.000000 0.0 60.000000	n new property and an extensive and a supplemental property of the property of the supplemental property of the supplemental supplement	CIEXP=	0.0	1.00000	
		ATED VALUES (T X DF)XX(CDEXP	KG) X CF	SUM TO	1.1.9.1			\$,MILLIONS 152.844	
		X (M)XX(CIEXP) X	CF X TF					0.010	
B-126	#RM = T / M E = 1.0 + (LOG(PHI) / LOG(2	.01					600.000 1.000	· James · · · · · · · · · · · · · · · · · · ·
	CTFU=(CLRM /	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				6.000	
		/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3		0.0	
	CIPS= CTB*Z4.	CTB X R						0•0 0•0	
. ~ .		D&M OR CTB*Z5/Z2	/ENYR					0.0	•
	COMMENTS								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.10 SECONDARY STRUCTURE - INTERFACE

		INPUT P	ARAMETERS			INP	UT COEFFICIENTS	
	T=	15500.0000	TF=	0.007300		CDCER=	0.156000	
	M =	5.000000	=M30	0.0		CDEXP=	0.511000	
	CF=	1.000000	Z 1 =	1.000000		CICER=	0.101000	
	PH I=	1.000000	Z 2=	60.000000		CIEXP=	0.355000	. 1
	R≕	0.0	Z 3 =	0.0				
	DF=	0.500000	Z 4=	60.000000	Z5 =			
	CALCUL	ATED VALUES	KG	SUM TO	1.1.9.1		\$, MILL IONS	
 1 4	CD=CDCER X	(T X DF)XX(CDEXP	X CF				15.155	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				0.001	
ä	#RM =T / M						3100.000	
.127	E =1.0 +	LOG(PHI) / LOG(2	.0)				1.000	· Consequents on the control of
	CT FU= (CLRM	/ E)X((#PM X Z1+	.5)XX(E) -	0.5XX(E))			4-047	
	CTB = (CLRM	/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / 23	0.0	
	CIPS=CTB*Z4	/12			چىلۇدىلىپىدى كىسات ئارىم		0.0	المتدالين وها المهيدي
	CRCI =	CTB X R					0.0	
	C 08 M =	O&M OR CTB*Z5/Z2	/ENYR				0.0	
	COMMENTS	gram (m. 1944). 1947 - Marie Marie Marie Marie (m. 1944). 1948 - Marie Marie (m. 1944).						The management was tree.
				(注) ないしょうしょ あいもってい				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.11 MECHANISMS - INTERFACE

		INPUT P	ARAMETERS	1 - 1 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 -		1 N	PUT COEF	FICIENTS	
	T= M= CF= PHI= R= DF=	391000.000 391.000000 1.000000 0.0 0.500000	TF= O&M= Z1= Z2= Z3= Z4=	1.000000 0.0 1.000000 60.000000 0.0 60.000000	Z5 =	CDCER= CDEXP= CICER= CIEXP=	0.0	0.156000 0.511000 0.000764 0.950000	
	CD=CDCER X (TED VALUES T X DF)XX(CDEXP (M)XX(CIEXP) X		SUM TO 1.	1.9.1			\$,MILLIONS 78.868 0.222	
B-128	· Andrews Andrews - Andrew	OG(PHI) / LOG(2 E)X((#RM X Z1+	in variati i seen illi li gillaadaan (bada)a Tara	5XX(E))				1.000 1.000 221.647	
ing protection of	CTB =((CLRM/ CIPS=CTB*Z4/ CRCI =C		3 + 0.5)XX(E)	-0.5XX(E))) / 23		0.0 0.0 0.0	
		EM OR CTB*Z5/Z2	/ENYR					0.0	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.12 CONDUCTORS & INSULATION

	INPUT PARAMETERS	en e	INPUT COEFF	ICIENTS
· · · · · · · · · · · · · · · · · · ·	M= 1650.00000 06M= 0. CF= 1.000000 Z1= 1.	0 000000	CDEXP= CICER=	0.158000 0.297000 0.000004 1.000000
	R= 0.0 Z3= 0. DF= 1.000000 Z4= 60.	0 000000 Z5 =	0.0	
	CALCULATED VALUES KG S	UM TO 1.1.9.1		\$,MILLIONS
	CD=CDCER X (T X DF)XX(CDEXP) X CF		en e	3.993
	CLRM=CICER X (M)XX(CIEXP) X CF X TF			0.007
B	#RM = T / M	Adam Angarang Angarang Angarang		31.994
129	E =1.0 + LOG(PHI) / LOG(2.0)			1.000
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)			0.211
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5	XX(E))) / Z3	0.0
	CIPS=CTB*Z4/Z2			0.0
	CRCI = CTB X R			0.0
	CC&M = O&M OR CTB*Z5/Z2/ENYR			0.0
	COMMENTS			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.13 SLIPRING BRUSHES - PRECURSOR

		INPUT P	ARAMETERS	en 🛥 en		IN	PUT COE	FICIENTS	Antonio (1944) este de la companio (1944). O porto de la companio (1944) este de la companio (1944) este de la companio (1944) este de la companio (1944)	
	T=	11341.0000 531.000000 1.000000 1.000000	TF= O&M= Z1= Z2=	1.000000 0.0 1.000000 60.000000		CDCER = CDEXP = CICER = CIEXP =		0.158000 0.297000 0.000200 1.000000		
	R= DF=	0.0 1.000000	Z3= Z4=	0.0 60.000000	Z5 =		0.0			
		ATED VALUES (T X DF)XX(CDEXP	KG) X CF	SUM TO	1.1.9.1			\$•MILL 2•529		
ᅜ	CLRM=CICER #RM =T / M	X (M)XX(CIEXP) >	CF X TF					0.106 21.358		
3-130:		LOG(PHI) / LOG(2	. • 0)					1.000		
	CTFU= (CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))			unannos de un deservado, não en compo name	2.268		
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		0.0		
	CIPS=CTB*Z4 CRCI =	/Z2 CTB X R					an	0.0		
		O&M OR CTB*Z5/Z2	/ENYR					0.0		
	COMMENTS									

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.14 PRIMARY STRUCTURE - POWER TRANS

	INPUT PARAME	TERS	eren i en la companya de la companya	INPUT	COEFFICIENTS	and the second s
·	T= 5000.00000 TF M= 1250.00000 0&M CF= 1.000000 Z1 PHI= 1.000000 Z2	= 0.0 = 1.000000		CDCER= CDEXP= CICER= CIEXP=	0.023000 0.800000 0.000050 1.000000	
	R= 0.0 Z3 DF= 1.000000 Z4		25=	0.	A CONTRACTOR OF THE CONTRACTOR	The second secon
	CALCULATED VALUES	KG SUM TO	1.1.9.1		\$, MILL IONS	
*	CD=CDCER X (T X DF)XX(CDEXP) X C	F			20.936	
	CLRM=CICER X (M)XX(CIEXP) X CF X	TF			0.063	
B-131	#RM =T / M				4.000	
131	E =1.0 + LOG(PHI) / LOG(2.0)			and the second of the second o	1.000	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX	(E) -0.5XX(E))			0.250	
	CTB = ((CLRM/E)X((#RM X Z3 + 0	.5)XX(E) -0.5XX(E))) / Z3	0.0	ven-early C at most contain designature, and defections also
	CIPS=CTB*Z4/Z2	in the property of the second second in the second			0.0	
	; CRCI =CTB X R				0.0	· ·
	CC&M = O&M OR CTB*Z5/Z2/ENYR				0.0	•
w,	COMMENTS				e de la composition br>La composition de la	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.1.9.1.15 SECONDARY STRUCTURE - POWER TRANS

	INPUT PARAMETERS		INPU	COEFFICIENTS
	T= 9750.00000 TF= 0.007300 M= 5.000000 0&M= 0.0 CF= 1.000000 Z1= 1.000000 PHI= 1.000000 Z2= 60.000000		CDCER= CDEXP= CICER= CIEXP=	0.156000 0.511000 0.101000 0.355000
	R= 0.0 Z3= 0.0 DF= 1.000000 Z4= 60.000000	25 =	0.	e da madamini kan kada sa da
	CALCULATED VALUES KG SUM TO	1.1.9.1	**************************************	\$, MILL IONS
	CD=CDCER X (T X DF)XX(CDEXP) X CF			17.041
	CLRM=CICER X (M)XX(CIEXP) X CF X TF			0.001
В	#RM =T / M			1950.000
B-132	E =1.0 + LOG(PHI) / LOG(2.0)			1.000
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))			2.546
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) $-0.5XX(E)$)) / Z3	0.0
- 1	CIPS=CTB*Z4/Z2	بعد بوید سد. کاما داد		0.0
	CRCI =CTB X R			0.0
	CO&M = O&M OR CT8*Z5/Z2/ENYR			0.0
	COMMENTS			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.16 TRANSMITTER SUBARRAYS - KLYSTRONS ICI

er A francisco con con con con con con con con con c	INPUT PARAMETERS	INPUT COEFFICIENTS
	T= 34617.0000 TF= 1.000000 M= 118.800003 O&M= 0.0 CF= 1.250000 Z1= 1.000000 PHI= 1.000000 Z2= 60.000000 R= 0.0 Z3= 0.0 DF= 1.000000 Z4= 60.000000	CDCER = 0.0 CDEXP = 0.0 CICER = 0.003270 CIEXP = 1.000000
	CALCULATED VALUES SQ M SUM TO 1 CD=CDCER X (T X DF)XX(CDEXP) X CF	1.1.9.1 \$,MILLIONS 0.0
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.486
B-133	#RM =T / M E =1.0 + LOG(PHI) / LOG(2.0)	291.389 1.000
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	141.497
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3 0.0
	CIPS=CTB*Z4/Z2	0.0
	CRCI = CTB X R	0.0
	CC&M = O&M OR CTB*Z5/Z2/ENYR COMMENTS	0.0

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.17 SWITCHGEAR & CONVERTERS - P.T. PRECURSOR

	INPUT P	INPUT PARAMETERS				INPUT COEFFICIENTS				
	T= 79200.0000 M= 2447.00000 CF= 1.500000 PHI= 1.000000 R= 0.0	TF= 0&M= Z1= Z2= 73=	1.000000 0.0 1.000000 60.000000	CDCER= CDEXP= CICER= CIEXP=		0.158000 0.297000 0.000400 1.000000				
	DF= 1.000000	24=	60.000000	Z5 =	0.0					
	CALCULATED VALUES	KG	SUM TO 1	.1.9.1		\$.MILLIONS				
	CD=CDCER X (T X DF)XX(CDEXP) X CF		· · · · · · · · · · · · · · · · · · ·		6.756				
	CLRM=CICER X (M)XX(CIEXP) >	CF X TF				1.468				
₽.	#RM =T / M					32.366				
B-134	E =1.0 + LOG(PHI) / LOG(2		1.000							
	CTFU=(CLRM / E)X((#RM X Z1+	.5)XX(E) -(0.5XX(E))			47.520				
	CTB = ((CLRM/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3		0.0				
	CIPS=CTB*Z4/Z2	n i La Paramaria Marajara				0.0				
	CRCI =CTB X R		ing di kacamatan di Kabupatèn Bandaran di Kabupatèn Bandaran di Kabupatèn Bandaran di Kabupatèn Bandaran di Ka Kabupatèn Bandaran di Kabupatèn Bandaran di Kabupatèn Bandaran di Kabupatèn Bandaran di Kabupatèn Bandaran di K			0.0				
	CCEM = OEM OR CTB*Z5/Z2	/ENYR				0.0				
	COMMENTS									

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.18 CONDUCTORS & INSULATION - P.T. PRECURSOR

	INPUT	PARAMETERS			11	IPUT COE	FICIENTS
T= M= CF= PH I= R=	60000.0000 1720.00000 1.000000 0.0	TF= 0&M= Z1= Z2= Z3=	1.000000 0.0 1.000000 60.000000 0.0		CDCER = CDEXP = CICER = CIEXP =		0.158000 0.297000 0.000004 1.000000
DF=	1.000000	Z 4=	60.000000	Z5 =		0.0	\$,MILLIONS
	(T X DF)XX(CDEX		SUM 10	1.1.7.1			4.147
CLRM=CICFR	X (M)XX(CIEXP)	CF X TF					0.007
#RM =T / M E = 1.0 +	LOG(PHI) / LOG(2	2.0)					34.884 1.000
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))							0.240
CTB = ((CLRM	1/E)X((#RM X 2	23 + 0.5)XX(E) -0.5XX(E))) / Z3		0.0
CIPS=CTB*Z4							0.0
	CTB X R O&M OR CTB*Z5/Z2	2/ENYR					0.0
COMMENTS							

		ROCKWE	LL SPS	CR-2	REFERENCE	CONFIGURATION
TABLE	1.1.9	.1.19	BATTERI	ES -	P.T. PRECU	IRSOR

	그리 수는 아이들이 되었다면 하는 것이다.					
	INPUT PARAMETERS	INPUT COEFFICIENTS				
	T= 8000.00000 TF= 1.000000	CDCER = 0.037000				
	M= 50.000000 DεM= 0.0	CDEXP= 0.734000				
	CF= 1.000000 Z1= 1.000000	CICER= 0.028000				
	PHI= 1.000000 Z2= 60.000000	CIEXP= 0.241000				
	R= 0.0 Z3= 0.0					
	DF= 1.000000 Z4= 60.000000	25=0.00				
	CALCULATED VALUES KG SUM TO 1.	.9.1 \$, MILLIONS				
	CD=CDCER X (T X DF)XX(CDEXP) X CF	27.106				
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.072				
ᄧ	#RM =T / M	160.000				
B-136	E =1.0 + LOG(PHI) / LOG(2.0)	1.000				
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	11.501				
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) $-0.5XX(E)$)) / Z3 0.0				
	CIPS=CTB*Z4/Z2					
	CRCI =CTB X R	0.0				
	COEM = OEM OR CTB*Z5/Z2/ENYR					
	COMMENTS	is magazini katan menggun inig memerenin kelimpatika ngandan para baharan katan katan menerengan sebenasi seba Katan dan menerengan katan menerengan berandan dan baharan dan baharan dan baharan dan beranda beranda beranda Katan dan menerengan berandan dan beranda dan beranda dan beranda beranda beranda beranda beranda beranda ber				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.20 THERMAL CONTROL - INSULATION - PRECURSOR

	INPUT PARAMETERS					INPUT COEFFICIENTS					
	T=	23200.0000 4.000000 1.000000 0.0	TF= 0&M= 21= 22= 23=	0.048000 0.0 1.000000 60.000000 0.0	CD CI CI	CER= EXP= CER= EXP=	0.156000 0.511000 0.101000 0.355000				
	D.F =	1.000000	Z 4=	60.000000	Z5 =	0.0					
	CALCULA	TED VALUES	KG	SUM TO 1.	1.9.1		\$,MILLIONS				
	CD=CDCER X (T X DF)XX(CDEX	P) X CF		ر المعلق الم المعلق المعلق المعل		26.539				
	CLRM=CICER X	(M)XX(CIEXP)	X CF X TF				0.008				
ద	#RM =T / M	entia versione de la companya de la					5800.000				
137'	E = 1.0 + L	OG(PHI) / LOG(2	2.0)				1.000				
	CTFU=(CLRM /	E)X((#RM X Z14	5)XX(E) -0.	.5XX(E))			4 5.996				
	CTB = ((CLRM/	E)X((#RM X 2	23 + 0.5)XX(E	E) -0.5XX(E))		/ Z3	0.0				
	CIPS=CTB*Z4/	Z2 11 11 11 11 11 11 11 11 11 11 11 11 11	ang galak tahun ang bersalah di a Ag		دوند افتال المطلق الداد المرازع المطلق الداد						
·	CRCI = C	TB X R									
	CC&M = O	EM OR CTB*Z5/Z2	2/ENYR				0.0				
	COMMENTS					No. 1 provide name of the contract of the cont	yeri da inga kangangan da ulau da inga kangan Panganan da inggalawan da i Panganan da inggalawan da i	ريش د خياست بالتوسيسية .			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.1.9.1.21 REFERENCE FREQUENCY GENERATOR - PRECURSOR

	INPUT P	ARAMETERS		INPUT COEFFICIENTS					
	1.000000	TF=	1.000000	CDCER=	0.500000				
M=	1.000000	=M30	0.0	CDEXP=	1.000000				
C F=	1.000000	Z 1 =	1.000000	CICER=	0.100000				
PHI=	1.000000	Z 2 =	60.000000	CIEXP=	1.000000				
R=	0.0	Z3=	0.0						
DF=	1.000000	Z 4=	60.000000	Z5 = 0.					
CALCULA	TED VALUES	SET	SUM TO 1.	1.9.1	\$, MILL IONS				
CD=CDCER X (T X DF)XX(CDEXP) X CF			0.500				
CLRM=CICER X	(M)XX(CIEXP) X	CF X TF			0.100				
#RM =T / M					1.000				
E =1.0 + L(G(PHI) / LOG(2	.0)			1.000				
CTFU={CLRM /	E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))		0.100				
CTB = ((CLRM/	E)X((#RM X Z	3 + 0.5) XX(E) -0.5XX(E))	1 / 23	0.0				
CIPS=CTB*Z4/Z	72				0.0				
CRCI =C	TB X R				0.0				
CC&M = 08	CM OR CTB*Z5/Z2	/ENYR			0.0				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.22 DIST. SYSTEM, COAXIAL CABLE

	INPUT PARAMETERS				INPUT COEFFICIENTS					
:	T= M= CF= PHI=	8613.00000 261.000000 1.000000 1.000000	TF= O&M= Z1= Z2=	1.000000 0.0 1.000000 60.000000	CDCE CDEX CICE CIEX	P = :R =	0.000030 1.000000 0.000060 1.000000			
	R= DF=	0.0 1.000000	Z 3= Z 4=	60.00000	Z5 =	0.0				
	CALC	ULATED VALUES	M	SUM TO 1	.1.9.1		\$,MILLIONS			
	CD=CDCER :	X (T X DF)XX(CDEXP) X CF				0.258			
	CLRM=CICE	R X (M)XX(CIEXP) X	CF X TF				0.016			
ᄧ	#RM =T / 1	M					33.000			
-	E =1.0 +	+ LOG(PHI) / LOG(2	.0)			in the second second second second second	1.000			
	CTFU=(CLR	M / E)X((#RM X Z1+	.5)XX(E) -0	•5XX(E))			0.517			
	CTB = ((CL	RM/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))	, ,	Z 3	0.0			
··············	CIPS=CTB*7	74/72					0.0			
	CRCI	=CTB X R					0.0			
	CC&M =	= O&M OR CTB*Z5/Z2	/ENYR				0.0			
	COMMENTS							en e		

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.23 DIST. SYSTEM DEVICES

	INPUT PARAMETERS					INPUT COEFFICIENTS					
	T=	100.000000	TF=	1.000000		CDCER=	0.000225				
	M=	2.000000	=M30	0.0		CDEXP=	1.000000				
	C F=	1.000000	Z 1 =	1.000000		CICER=	0.005000				
······································	PH I =	1.000000	Z2=	60.000000		CIEXP=	1.000000	المعلى المعالجين المعالجين المعالجين المعالجين			
٠	R≡	0.0	Z3=	0.0	7.5						
	DF=	1.000000	Z 4=	60.000000	Z5 =	0.	0				
	CALCUL	ATED VALUES	KG	SUM TO 1	.1.9.1		\$,MILLIONS				
	CD=CDCER X	(T X DF)XX(CDEXP) X CF			e and a second of the second of the second	0.022				
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				0.010				
₩	#RM = T / M						50.000				
B-140	E =1.0 + LOG(PHI) / LOG(2.0)						1.000				
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))						0.500				
	CTB = ((CLRM	1/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3	0.0				
	CIPS=CTB*Z4	4/Z2		en e			0.0	one en e			
	CRCI =	=CTB X R					0.0				
	COEM =	O&M OR CTB*Z5/Z2	/ENYR				0.0	1. 1			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.1.24 TRANSMITTER SUBARRAYS - KLYSTRONS DDT&E

INPUT PARAMETERS					INPUT COEFFICIENTS				
T= M= CF=	282500.000 282500.000 1.250000	TF= 0&M= Z1=	1.000000 0.0 1.000000		CDCER = CDEXP = CICER =		0.205000 0.507000 0.0		
PHI=	1.000000	Z 2=	60.000000		CIEXP=		0.0		
R= DF=	0.0 1.000000	Z 3= Z 4=	60.000000	Z5 =		0.0			
CALCUL	ATED VALUES	KW	SUM TO	1.1.9.1			\$, MILLIONS		
CD=CDCER X	(T X DF)XX(CDEXP	X CF				· ·	148.707		
CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					0.0		
#RM =T / M							1.000		
1 4 E = 1.0 +	E =1.0 + LOG(PHI) / LOG(2.0)								
CTFU=(CLRM	/ E)X((#RM X Z1+	5)XX(E) -0.5	5XX(E))				0.0	· • · · · · · · · · · · · · · · · · · ·	
CTB = ((CLR)	M/E)X((#RM X Z	3 + 0.5)XX(E)	-0.5XX(E))) / Z3		0.0		
CIPS=CTB*Z4	4/22	er en en er en	e en	de man a madas per peri de un relevero de el la			0.0		
CRCI =	ECTB X R						0.0	waanimad ay waxay aanaabi	
	0&M OR CTB*Z5/Z2	?/ENYR					0.0		
COMMENTS									

1.1.9.2 EOTV PRECURSOR OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the precursor test activity.

Cost estimates are presented in Table 1.1.9.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.1.9.2 COTV PRECURSOR OPERATIONS

	INPUT PARAMETERS	en e	INPUT COEFFICIENTS					
	T= 1.000000 TF= M= 1.000000 D&M= CF= 1.000000 Z1= PHI= 1.000000 Z2= R= 0.0 Z3=	1.000000 0.0 1.000000 60.000000		CDCER = CDEXP = CICER = CIEXP =		0.0 0.0 0.630000 1.000000		
	DF= 1.000000 Z4=	60.000000	25=		0.0			
<u>-</u> -	CALCULATED VALUES FLIGHT	SUM TO	1.1.9			\$,MILLI	ONS	
	CD=CDCER X (T X DF)XX(CDEXP) X CF		· · · · · · · · · · · · · · · · · · ·			0.0		
	CLRM=CICER X (M)XX(CIEXP) X CF X TF					0.630		
쁄	#RM =T / M					1.000		
143	E =1.0 + LOG(PHI) / LOG(2.0)	nakan republik melanca permanan permanan dari sebahan bahasa dalah	and the state of t		n garanta sayan sa sakan sa kabangan sagayan da yan sasa sa sana sa	1.000		
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5	5XX(E))				0.630		
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E)	-0.5XX(E))) / Z3		0.0		
	CIPS=CTB*Z4/Z2					0.0		
	CRCI =CTB X R		······································			0.0		
	COEM = OEM OR CTB*Z5/Z2/ENYR					0.0	*	
•	COMMENTS							

1.2 SPACE CONSTRUCTION AND SUPPORT

This element includes all hardware and activities required to assemble, checkout, operate, and maintain the satellite system. Included are space stations, construction facilities, support facilities and equipment, and manpower operations.

The Rockwell reference configuration is used as a baseline for the development of a satellite construction scenario and construction systems/equipment. Precursor operations incident to the establishment of orbital support facilities were identified and the satellite construction sequences and procedures were developed.

The overall scenario leading to establishment of satellite construction support facilities and to satellite construction is shown in Figure 1.2-1. Initial operations entail use of the growth shuttle and the shuttle derived HLLV for transporting men and material to LEO for the precursor phase of the program. Subsequently, during the 30 year satellite construction phase, the sps HLLV will become the primary transportation element for delivering construction mass to LEO and the shuttle HLLV will be used for personnel transfer to LEO.

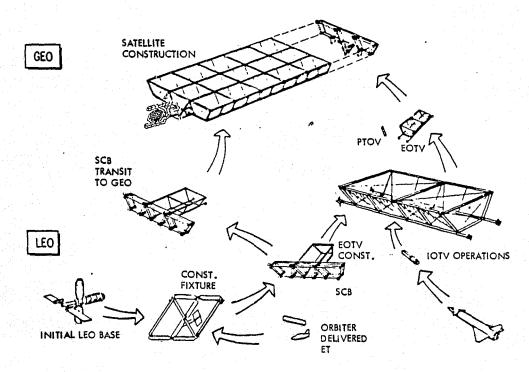


Figure 1.2-1. Overall Satellite Construction Scenario

The initial step in satellite precursor operations is establishment of a LEO base as shown in the lower left of the figure. Crew and power modules are transported to LEO by shuttle derivatives and assembled. When the base is fully operational, shuttle external tanks are delivered and mated to form

construction fixtures for the Satellite Construction Base (SCB) construction. The figure shows a completed SCB. Since the more economical SPS HLLV will not be available during this phase of the program, and since overall plans specify an EOTV test article, it is possible that only the center section of the SCB would be constructed initially. This trough would be used to fabricate the pilot plant EOTV test article with an end-mounted antenna. After proof of concept, the remainder of the SCB would be completed along with sufficient EOTVs to support initial satellite construction operations. The SCB will then be transferred to GEO, using one or more EOTVs for propulsion and attitude control. Upon reaching GEO, satellite construction would commence, with the logistics support as shown at the right of the figure.

The energy conversion segment of the satellite structure is constructed by the integrated SCB in a single pass. Satellite longerons of a length sufficient to connect the triangular frames of the slip ring support structure are fabricated, followed by construction of the slip ring interface structure, and the first satellite structure frame. The SCB then proceeds to fabricate/install the remainder of the satellite structure and solar converter. Construction of the slip rings, and yoke (interface) takes place concurrently using free flying fabrication facilities to support this building process (Figure 1.2-2).

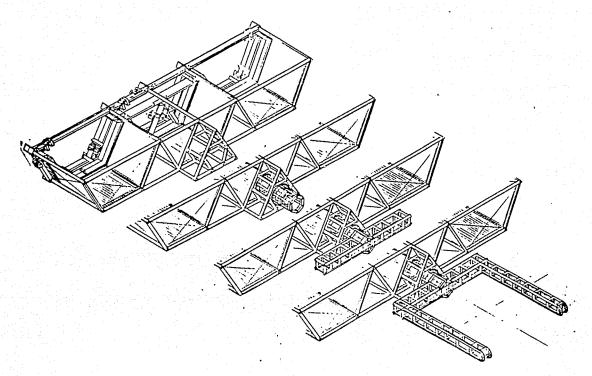


Figure 1.2-2. Antenna Supporting Structure Assembly Sequence

This section addresses the facilities/equipment, and operations required to support SPS work, crew, and operational requirements during the SPS program. Section 1.2.1 deals with the construction facilities; and Section 1.2.2 deals with the work and crew requirements at LEO. Section 1.2.3 covers the requirements in GEO to support operations and maintenance of the satellite.

1.2.1 CONSTRUCTION FACILITIES

This element includes the facilities, equipment, and operations required to assemble and checkout the satellite system. Included are crew life support facilities, the central control facility, fabrication and assembly facilities, cargo depots, and operations.

The satellites are constructed in GEO, each satellite being constructed at its designated longitudinal location. The SCB supports construction of two satellites per year during the program and serves as headquarters for operations and activities necessary to construct such items as the satellite, antenna interface, antenna, and EOTV. The SCB is constructed of composites and consists of the fabrication fixture, construction equipment, and base support facilities.

The construction fixture is in the form of three troughs, corresponding to the satellite configuration, which permits simultaneous construction of all troughs. Additional structural members are located in the middle trough and are used as support for the rotary joint/antenna structure. Figure 1.2-3 illustrates the construction base and shows the location of work and crew facilities.

The SCB fabrication fixture assembly and support equipment, and the crew/work modules on the base are itemized in Table 1.2.1. SCB modules used to support the crew/work activities are of various internal configurations to accommodate specific functional requirements. All modules are of the same diameter and most are of the same length, their dimensions and mass being in compliance with space transportation system constraints. The modules are located on the fab fixture along with the assembly and support equipment.

The Airlock Docking Module (ADM) is used to join the other base modules to provide docking accommodations for other elements such as crew transport modules, consumables logistics modules (CLM) and intra-base logistics vehicles, and for transfer of personnel and equipment between different pressure environments. The Crew Habitability Module (CHM) provides stateroom and personal hygiene facilities, and support systems for 24 to 30 crew members. The Base Management Module (BMM) houses the operational communications and control systems for the base. Power Modules (PM) are photovoltaic power systems (collectors, converters, conditioners, and storage) which support all base power requirements. Pressurized Storage Modules (PSM) provide an area for storage and workshop accommodations. Shielding (SHD) is provided in selected modules to protect against solar flare radiation. The Crew Support Module (SM) provides the galley, recreational and medical facilities and support subsystems. Work support, crew, and operational requirements are discussed in the following paragraphs.

1.2.1.1 WORK SUPPORT FACILITIES - SCB

This element includes work facilities and equipment required for satellite assembly and checkout. Included are beam fabricators, manipulators, assembly jigs, installation and deployment equipment, and cargo storage depots. Excluded are the facilities related to crew support.

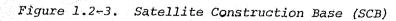






Table 1.2.1 Total Space Construction and Support Equipment Requirements

		SPACE CONSTRUCTION BASE			
SYSTEM DESCRIPTION	ABBREVIATION	WORK SUPPORT FACILITIES	CREW SUPPORT FACILITIES		
BASE MODULES: AIRLOCK DOCKING MODULE CREW HABITABILITY MODULE CONSUMABLES LOGISTICS MODULE BASE MANAGEMENT MODULE CREW SUPPORT MODULE/EVA POWER MODULE PRESSURIZED STORAGE MODULE SHIELDING CREW SUPPORT MODULE CREW REQUIREMENTS	ADM CHM CLM BMM CSM/EVA PM PSM SHD CSM	17 4 4 4	5 17 9 8 3 317 AVG. 504 PEAK		
ASSEMBLY AND SUPPORT EQUIPMENT: BEAM MACHINES BEAM MACHINE-CASSETTES CABLE ATTACHMENT MACHINES REMOTE MANIPULATOR SOLAR BLANKET DISPENSER MACHINE SOLAR BLANKET CASSETTES REFLECTOR DISPENSER MACHINES REFLECTOR CASSETTES CABLE/CATENARY DISPENSERS ANTENNA PANEL INSTALL. EQUIP. GANTRY/CRANES CARGO STORAGE DEPOT SCB FAB FIXTURE		198 3618 72 110 72 5760 6 360 84 !			

SCB modules used mainly in the support of construction operations include a total of 17 ADMs, 4 BMMs, 4 PMs, and 4 PSMs. The CERs used for these modules were based on Rockwell Space Station studies.

All SPS unique fabrication/orbital construction assembly and support equipment is included in this section (reference Table 1.2.1). Included are the tribeam fabricators, cable attachment machines, solar blanket/concentrator dispensing machines, and antenna panel installation equipment. Each of these requirements were analyzed for equipment usage, replacement factors, 0&M, and projected costs based on engineering estimates of design characteristics. The items of assembly and support equipment and base modules remain on the SCB as it transfers from one construction site to another. Cost estimates for these items are presented in Tables 1.2.1.1.1 through 1.2.1.1.17.

1.2.1.2 CREW SUPPORT FACILITIES - SCB

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, central control facilities, recreation facilities, and health facilities of the satellite construction base.

Crew support facilities include 5 ADMs, 17 CHMs, 9 CLMs, 8 SLDs, and 3 CSMs. Detail cost sheets on these components are identified in Tables 1.2.1.2.1 through 1.2.1.2.5.

1.2.1.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the construction facility. It includes both the direct and support personnel and the expendable maintenance supplies for satellite assembly and checkout.

This element has been divided into the subelements of operations (Table 1.2.1.3.1) and consumables (Table 1.2.1.3.2) where an average crew of 317 persons is required to man the SCB over the normal six month fabrication period. A crew rotation is scheduled for every three months. Consumables for the SCB are calculated at 3.6 kg/person/day.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.1 BEAM MACHINE

-	INPUT PARAMETERS	INPUT COEFFICIENTS	
	T= 1.000000 TF= 1.000000 M= 1.000000 0&M= 0.594000 CF= 1.000000 Z1= 198.000000 PHI= 0.920000 Z2= 60.000000	CDCER= 2.000000 CDEXP= 1.000000 CICER= 0.700000 CIEXP= 1.000000	
	R= 0.0 Z3= 198.000000 DF= 1.000000 Z4= 198.000000 Z5=	• 0.0	
	CALCULATED VALUES SUM TO 1.2.1.1	\$, MILLIONS	
	CD=CDCER X (T X DF)XX(CDEXP) X CF	2.000	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.700	
ъ	#RM =T / M	1.000	
150	E =1.0 + LOG(PHI) / LOG(2.0)	0.880	
****	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	83.150	
	CTB = $((CLRM/E)X((\#RM X Z3 + 0.5)XX(E) - 0.5XX(E))$) / Z3 0.420	
a	CIPS=CTB*Z4/Z2	1.386	
-	CRCI =CTB X R	0.0	
	CO&M = O&M OR CTB*Z5/Z2/ENYR COMMENTS	0.594	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.2 BEAM MACHINE CASSETTES

		INPUT P	ARAMETERS			IN	PUT C	DEFFICIENTS	
		1.000000	TF=	1.000000		CDCER=		0.800000	
	M= 1	1.000000	=M30	0.090450		CDEXP=	· · · · · · · · · · · · · · · · · · ·	1.000000	······
	CF=	1.000000	Z1=	1206.00000		CICER=		0.008200	
	PHI=	0.950000	Z2=	60.000000		CIEXP=		1.000000	•
	R=	0.066667	Z3=	3618.00000					
	DF=	1.000000	Z4=	1206.00000	Z5 =		0.0		
	mandar and antique and a contract of the contr								
	CALCULATE	D VALUES		SUM TO	1.2.1.1			\$, MILLIONS	
	CD=CDCER X (T	X DF)XX(CDEXP	X CF					0.800	
	CLRM=CICER X (M)XX(CIEXP) X	CF X TF					0.008	
ਸ਼ 	#RM =T / M							1.000	
7	E = 1.0 + LOG	(PHI) / LOG(2	.0)				جادیوست	0.926	
	CTFU=(CLRM / E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				6.315	
	CTB = ((CLRM/E)	X ((# R M X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3		0.005	
	CIPS=CTB*Z4/Z2							0.097	
······································	CRCI =CTB	X R				······································		0.000	
	CCEM = OEM	OR CTB*Z5/Z2	/ENYR					0.090	
	COMMENTS								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.2.1.1.3 CABLE ATTACHMENT MACHINE

	INPUT PARAMETER	<u> </u>	IN	PUT COEF	FICIENTS	
T= M= CF= PHI= R= DF=	1.000000 TF= 1.000000 O&M= 1.000000 Z1= 0.950000 Z2= 0.0 Z3= 1.000000 Z4=	1.000000 0.144000 72.000000 60.000000 72.000000	CDCER= CDEXP= CICER= CIEXP= Z5=	0.0	4.300000 1.000000 0.500000 1.000000	
CD=CDCER X (1	TED VALUES T X DF)XX(CDEXP) X CF	SUM TO 1	.2.1.1		\$, MILL IONS 4.300	
#RM =T / M	(M)XX(CIEXP) X CF X TF				0.500 1.000 0.926	
CTFU=(CLRM /	E)X((#RM X Z1+.5)XX(E)			28.228		
CTB = ((CLRM/E CIPS= CTB*Z4/Z CRCI = CT		XX(E) -0.5XX(E))) / 23		0.392 0.470 0.0	
COEM = OE	M OR CTB*Z5/Z2/ENYR				0.144	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.4 REMOTE MANIPULATOR

	INPUT PARAMETERS		araning ar y and any area and area.	• • • • • • • • • • • • • • • • • • •					
	T =	1.000000	TF=	1.000000		CDCER=		6.880000	
	M=	1.000000	=M30	1.925000		CDEXP=		1.000000	
	C F=	1.000000	Z 1 =	55.000000		CICER=		1.200000	
	PH I=	0.980000	Z 2=	60.000000	-4	CIEXP=		1.00000	
	R=	0.033333	23=	110.000000					
	DF=	1.000000	Z 4=	55.000000	Z5 =		0.0		
	CALCUL	ATED VALUES -		SUM TO 1	.2.1.1			\$,MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF					6.880	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					1.200	
B	#RM =T / M	والمراجعة	· · · · · · · · · · · · · · · · · · ·					1.000	
153	= 1.0 +	LOG(PHI) / LOG(2		0.971					
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))							60.390	
	CTB = $((CLRM/E)X((\#RM X Z3 + 0.5)XX(E) -0.5XX(E))$) / Z3		1.077	
	CIPS=CTB*Z4	/72			and the second second second	en e		0.987	
	CRCI =	CTB X R						0.036	
		CIU X K						U • U 36	
	= M3O3	0&M OR CT8*Z5/Z2	/ENYR					1.925	
** * .	COMMENTS							and the second s	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.5 BLANKET DISPENSER MACHINE

	INPUT PARAMETERS				INPUT COEFFICIENTS					
	T =	1.000000	TF=	1.000000	CDCER		4.00000			
	M=	1.000000	=M3O	0.180000	CDEXP		1.00000			
	C F=	1.000000	Z 1 =	72.000000	CICER		0.40000			
	PH [=	0.980000	Z2=	60.000000	CIEXP		1.000000			
	R=	0.0	23=	72.000000						
	DF=	1.000000	Z 4=	72.000000	Z5 =	0.0				
	CALCULA	TED VALUES		SUM TO 1	.2.1.1		\$, MILL IONS			
	CD=CDCER X	T X DF XX CDEXP) X CF				4.000			
	CLRM=CICER >	((M)XX(CIEXP) X	CF X TF				0.400			
<u>в</u>	#RM = T / M						1.000			
B-154	E =1.0 + L	.OG(PHI) / LOG(2	.0)				0.971	en e		
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))						26.154			
	CTB = (CLRM /	'E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) /	Z3	0.363			
	CIPS=CTB*Z4/	722					0.436			
	CRCI = C	TB X R			·		0.0	rimmen (determenasjonan nivasjonasjon (ma) armana m		
	CO&M = 0	DEM OR CTB*Z5/Z2	/ENYR				0.180			
	COMMENTS									

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.6 SOLAR BLANKET CASSETTES

		INPUT P	ARAMETERS	· · · · ·		IN	PUT COEF	FICIENTS	
		1.000000	TF=	1.000000		CDCER=		0.800000	
	M=	1.000000	=M3O	0.115200		CDEXP=	*.	1.000000	
	CF=	1.000000	Z 1 =	1440.00000		CICER=		0.010000	
	PHI=	0.950000	Z 2=	60.000000		CIEXP=		1.000000	
	R=	0.066667	Z3=	5760.00000	the grade square days appear apply through the total the con-	The state of the s	And the same of th		
	0 F =	1.000000	Z4=	2880.00000	Z5 =		0.0		
	CALCULA	TED VALUES	<u> </u>	SUM TO	1.2.1.1			\$, MILLIONS	
	CD=CDCFR X (T X DF)XX(CDEXP) X CF					0.800	
	CLRM=CICER X	((M)XX(CIEXP) X	CF X TF					0.010	
B-1	#RM =T / M	<u></u>						1.000	
155	E = 1.0 + L	OG(PHI) / LOG(2	.0)					0.926	·
	CTFU=(CLRM /	' E)X((#RM X Z1+	.5)XX(E)	-0.5XX(E))				9.076	
	CTB = ((CLRM/	'E)X((#RM X Z	3 + 0.5)X	X(E) -0.5XX(E))) / Z3		0.006	
	CIPS=CTB*Z4/	722		en jaman kanala jaman kanala ja kanala j Kanala kanala kanala jaman kanal	Andrews of the second of the s			0.273	
· 	CRCI = C	TB X R				nga magampaga nga pagampaga maka baga		0.000	
	C 0 & M = C	1&M OR CTB*Z5/Z2	/ENYR					0.115	
	COMMENTS								e mai escal e cara e companione de companione de companione de companione de companione de companione de compa La companione de

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.7 REFLECTOR DISPENSER MACHINE

		INPUT PARAMETERS			<u></u>				
	Τ=	1.000000	TF=	1.000000		CDCER=	•	.000000	
	M=	1.000000	=M3O	0.048000		CDEXP=		.000000	
	CF=	1.000000	Z 1 =	6.000000		CICER=	(0.80000	
	PHI=	0.980000	Z2=	60.000000	and the second s	CTEXP=		.000000	The second control of
	R=	0.0	Z3=	6.000000					
	0 F=	1.000000	Z4=	6.000000	Z5 =		0.0		
	CALCULATE) VALUES		SUM TO	1.2.1.1		 	\$, MILL IONS	——————————————————————————————————————
	CD=CDCER X (T)	(DF)XX(CDEXP) X CF			g e de		6.000	
	CLRM=CICER X (N	A)XX(CIEXP) X	CF X TF					0.800	
В	#RM =T / M	alminima. Addresion - L.A.A Pt. saningar Lond & Ass. C. Alminima in Lancid china, Sinc						1.000	
B-156	E = 1.0 + LOG	PHI) / LOG(2	.0)		e and appearance and analysis and an experience		ر والاستان المستوالية السياسية الأراض	0.971	
	CTFU=(CLRM / E)	X((#RM X Z1+	.5)XX(E) -0	.5XX(E))				4.651	
Mary Auto-Control	CTB = $((CLRM/E)X((\#RM X Z3 + 0.5)XX(E) - 0.5XX(E))$) / Z3							0.775	
	CIPS=CTB*Z4/Z2						ing and the second of the seco	0.078	
	CRCI =CTB	X R				······································	vin Maritina and Artificial and Arti	0.0	and the second seco
	Mag = Mags	OR CTB*Z5/Z2	/ENYR					0.048	
	COMMENTS								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.8 REFLECTOR CASSETTES

INPUT PARAMETERS		INPUT (COEFFICIENTS	
1.000000 TF=	1.000000	CDCER=	1.00000	
M= 1.000000 D&M=	0.054000	CDEXP=	1.00000	***************************************
CF = 1.000000. $Z1 = 1.000000$	120.000000	CICER=	0.030000	
PHI= 0.950000 Z2=	60.000000	CIEXP=	1.000000	
R= 0.066667 Z3=	360.000000	And the second s	ngar in kanang menggalangan di Selatan di Selatan di Angarin di A	The same of the part of the contract of the co
DF= 1.000000 Z4=	120.000000	25= 0.0	in the property of the proper	
CALCULATED VALUES	SUM TO 1.	2.1.1	\$, MILLIONS	**************************************
CD=CDCER X (T X DF)XX(CDEXP) X CF			1.000	
CLRM=CICER X (M)XX(CIEXP) X CF X TF			0.030	
ж #RM = T / M			1.000	
E =1.0 + LOG(PHI) / LOG(2.0)			0.926	
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.	.5XX(E))		2.721	:
CTB = $((CLRM/E)X((\#RM X Z3 + 0.5)XX(E))$	E) -0.5XX(E))) / Z3	0.021	
CIPS=CTB*Z4/Z2			0.042	
CPCI = CTB X R			0.001	
CC&M = O&M OR CTB*Z5/Z2/ENYR			0.054	
COMMENTS				

IABLE	I.Z.I.I.9 CABLE/CAI	ENARY DISPENSER MA	CHINES				
	INPUT PARAMETI	ERS		IN	PUT COEF	FICIENTS	
T= M=	1.000000 TF= 1.000000 OcM=	0.168000		CDCER= CDEXP=		2.200000	Annau III - K. Na. uyy terjenesia, fishioteriy te-yalini - J
CF= PHI=	1.000000 Z1= 0.980000 Z2=			CICER= CIEXP=		0.300000 1.000000	
R= DF=	0.0 Z3= 1.000000 Z4=	84.000000	. I a ser anne in a sarage de s	A MATERIAL STATES	0.0		en e
CALCULA	TED VALUES	SUM TO	1.2.1.1		طستمجينه يجينون بالمائه الدوا مستديده في مطسور	\$, MILL IONS	andronaumina, naugust adamptinana Etropia anarrona.
CD=CDCER X (T X DF)XX(CDEXP) X CF				eri Stopherson	2.200	
CLRM=CICER X	(M)XX(CIEXP) X CF X	TF - Market Jack				0.300	
#RM =T / M				al transport de commission of commission (state of the commission of		1.000	and the second s
= 1.0 + L	OG(PHI) / LOG(2.0)			in de la compania de La compania de la co	S. S. Sansan and Season	0.971	
CTFU=(CLRM /	E)X((#RM X Z1+.5)XX(E) -0.5XX(E))			amendanisma (myan is sandaman) anda	22.786	- Novel - and responses determined and analysis of the same
CTB = (CLRM/	E)X((#RM X Z3 + 0.	5)XX(E) -0.5XX(E))) / 23		0.271	
CIPS=CTB*Z4/	22					0.380	
CRCI =C	TB X R	n de la companya del la companya de la companya de	e paragrama mandrina ya gang 150 manasa .	and the second of the second o	Annual Constitution of the	0.0	o e e e e e e e e e e e e e e e e e e e
CC&M = O	EM OR CTB*Z5/Z2/ENYR					0.168	

COMMENTS

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.10 ANTENNA PANEL INS. EQPT.

	INPUT PARAMETERS	INPUT COEFFICIENTS
	T= 1.000000 TF= 1.000000 M= 1.000000 O&M= 6.755000 CF= 1.000000 Z1= 1.000000 PHI= 0.980000 Z2= 60.000000 R= 0.0 Z3= 1.000000	CDEXP = 1.000000 CICER = 200.000000 CIEXP = 1.000000
:	DF= 0.133333 Z4= 1.000000	
	CALCULATED VALUES SET SUM TO CD=CDCER X (T X DF)XX(CDEXP) X CF	1.2.1.1 \$,MILLIONS 80.000
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	200.000
B-159	#RM =T / M E =1.0 + LOG(PHI) / LOG(2.0)	1.000 0.971
	CTFU=(CLPM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	200.272
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) $-0.5XX(E)$)) / Z3 200.272
	CIPS=CTB*Z4/Z2	3.338
	CRCI = CTB X R	0.0
	CORM = DRM OR CTB*Z5/Z2/ENYR COMMENTS	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.11 GANTRY/CRANES

		INPUT	PARAMETERS			INPUT CO	EFFICIENTS	
	T= M= CF=	1.000000 1.000000 1.000000	TF= O&M= Z1=	1.000000 0.600000 12.000000	CDCE CDEX CICE	P=	17.000000 1.000000 8.000000	a go committee des desirables de la committee
	PHI=	0.950000	7.2=	60.000000	CIEX		1.000000	
	R= DF=	0.0 0.800000	Z3= Z4=	12.000000 12.000000	Z5 =	0.0		
	CALCULA	TED VALUES		SUM TO 1.	2.1.1		\$, MILLION	S · · · · ;
	CD=CDCER X (T X DF)XX(CDEX	P) X CF				13.600	
	CLRM=CICER X	(M)XX(CIEXP)	X CF X TF				8.000	
B-1	#RM =T / M						1.000	
160	= 1.0 + L	OG(PHI) / LOG(2.0)		Carrier and the same of the same	and the second second	0.926	·
e per de deservir de la constante de la consta	CTFU=(CLRM /	E)X((#RM X Z1	+.5)XX(E) -0	.5XX(E))			85.034	allennas - Postanos areandos as ana popular - senda
	CTB = ((CLRM/	E)X((#RM X	Z3 + 0.5)XX(E) -0.5XX(E))	1 1	23	7.086	
	CIPS=CTB*Z4/	22	A transfer of the control of the con				1.417	an mengare waa
	CRCI =C	TB X R	management of the contract of the second				0.0	
	CC&M = O	EM OR CTB*Z5/Z	2/ENYR				0.600	
	COMMENTS							energia de percento de la composición del composición de la compos

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.12 CARGO STORAGE DEPOTS

		INPUT P	ARAMETERS			IN	PUT COEFFICIENTS		
	an T≕	1.000000	TF=	1.000000		CDCER=	15.000000		
	M=	1.000000	=M30	0.600000		CDEXP=	1.000000		
	CF=	1.000000	Z 1 =	4.000000		CICER=	2.000000		
	PHI=	0.950000	Z 2=	60.000000		CIEXP=	1.000000		
	R=	0.0	Z 3=	4.000000					
	DF=	0.800000	Z 4 =	4.000000	Z5 =		0.0		
	CALCUL	ATED VALUES	e . dia mandra da calar arrive de calar	SUM TO	1.2.1.1		\$,M	ILLIONS	<u></u>
	CD=CDCER X	(T X DF)XX(CDEXP) X CF				12.0	000	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				2.0	000	
뿌	#RM =T / M						1.000		
B-161	E =1.0 +	LOG(PHI) / LOG(2	. O J				0.926		1967 - 1968 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968 - 1968
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			7.5	559	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))		1 / 23	1.6	90	
	CIPS=CTB*Z4	/22					0.1	. 26	
	CRCI =	CTB X R					0.0)	
	CCEM =	O&M OR CTB*Z5/Z2	/ENYR				0.6	00	
	COMMENTS								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.13 FAB FIXTURE

	INPUT PA	RAMETERS			IN	PUT COEFFICIENTS
M= 5 C F=	900.00 000.00000 1.000000 0.0 1.000000	TF= 06M= Z1= Z2= Z3= Z4=	1.000000 0.0 1.000000 60.000000 1.000000	Z5 =	CDCER = CDEXP = CICER = CIEXP =	
CALCUL ATED		KG	SUM TO		mail Mail to Marketing programmers bear the Marketing	\$, MILLIONS
CD=CDCER X (T X						2165.128 0.250
#RM =T / M E = 1.0 + LOG(PHI) / LOG(2.	.0)				329.780 1.000
CTFU=(CLRM / E)	X((#PM X Z1+	.5)XX(E) -0	.5XX(E))		Automobile, at page anima	82.445
CTB = ((CLRM/E)X	((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	82.445
CIPS=CTB*Z4/Z2						1.374
CRCI = CTB	OR CTB*Z5/Z2	'ENYR				0.0
COMMENTS						

POCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.14 AIRLOCK DOCKING MODULE (ADM)

	INPUT PARAMETERS	INPUT	COEFFICIENTS	
	T= 2500.00000 TF= 1.000000 M= 2500.00000 D&M= 0.0 CF= 1.000000 Z1= 17.000000 PHI= 0.980000 Z2= 60.000000 R= 0.020000 Z3= 17.000000 DF= 1.000000 Z4= 17.000000	CDEXP= CICER= CIEXP= CIEXP=	0.0 0.0 0.006036 1.000000	
	CALCULATED VALUES KG SUM TO CD=CDCER X (T X DF)XX(CDEXP) X CF CLRM=CICER X (M)XX(CIEXP) X CF X TF	1.2.1.1	\$,MILLIONS 0.0 15.090	
B 163	#RM =T / M E =1.0 + LOG(PHI) / LOG(2.0)		1.000 0.971	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)) CTB =((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	242.302 14.253	
	CIPS=CTB*Z4/Z2 CRCI =CTB X R		4.038 0.285	- :
	CC&M = D&M OR CTB*Z5/Z2/ENYR COMMENTS SEE 1.2.1.2.1 FOR DDT&E		0.0	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.15 BASE MGMT. MODULE (BMM)

	I	N	P	U	T	ρ	AR	AM	E	T	Ε	R	S
--	---	---	---	---	---	---	----	----	---	---	---	---	---

INPUT COEFFICIENTS

	n T≓	27000.0000	TF=	1.000000		CDCER=	(0.0		
	M=	27000.0000	=M30	0.0	************	CDEXP=		0.0		
	CF=	1.000000	Z 1 =	4.000000		CICER=		0.011496		
	PH I =	0.980000	Z 2=	60.000000		CIEXP=	1	.000000		
	R=	0.020000	73=	4.000000						
	DF=	1.000000	Z 4=	4.000000	25 =		0.0			
***************	CALCUI	LATED VALUES	KG	SUM TO 1	.2.1.1	Processing to the State of Sta		\$,MILLIO	NS	
	CD=CDCER X	(T X DF)XX(CDEXF	X CF					0.0		
	CLRM=CICER	X (M)XX(CIEXP)	CCF X TF					310.392		
								310.372		
B-1	#PM =T / M	The second secon						1.000	e e i diaga (- Mi pergeliti e rata), e pi i meneramana dendeperanda distributiva di republika, papa	
L64	E =1.0 +	LOG(PHI) / LOG(2	.0)		. 			0.971	andria Barrian	
	CTFU= (CLRM	/ E)X((#RM X Z14	5)XX(E) -0	.5XX(E))				1213.870		
	CTR = ((CLRA	M/E)X((#RM X Z	3 + 0.51XX(F1 -0 5XX(F))	in the second section of the second section of the sec) / Z3		303.467	tra er - y prince te - garangaining e signing gray este - Atropia demakan	
	0, 0 (10E)(er oranner		, , ,		303.401		
	CIPS=CTB*Z	4/22						20.231		•
	CRCI =	=CTB X R	energia de la compania del la compania de la compania de la compania de la compania de la compania del la compania de la com			The content of the property of the content of the c		6.069	ng atronomies inga pengganangan gan	
	CCEM =	DEM OR CTB*Z5/Z2	/ENYR					0.0		
	COMMENTS SEE 1.2	2.2.1.1 FOR DOTER								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.16 POWER MODULE (PM)

		INPUT P	ARAMETERS			IN	PUT COE	FICIENTS	
	T= M= CF= PHI= R= DF=	250.000000 250.000000 1.000000 0.980000 0.020000 1.000000	TF= O&M= Z1= Z2= Z3= Z4=	1.000000 0.0 4.000000 60.000000 4.000000	25=	CDCER = CDEXP = CICER = CIEXP =	0.0	0.0 0.0 1.100000 1.000000	
• • • • • • • • • • • • • • • • • • • •	CALCULA	TED VALUES	KW	SUM TO	1.2.1.1		Addressed ander verby only produce Addition addressed	\$,MILLIONS	
	CD=CDCER X (T X DF)XX(CDEXP) X CF			en e		0.0	
	CLRM=CICER X	((M)XX(CIEXP) X	CF X TF					275.000	
ᄧ	#RM =T / M		eritari karan da asama ran marambara mengaharanak					1.000	
165	E = 1.0 + L	.0G(PHI) / L0G(2	.0)		ا الماريخ استعمادات			0.971	
	CTFU=(CLRM /	' E)X((#RM X Z1+	.5) XX(E) -0	.5XX(E))				1075.459	
	CTB = ((CLRM/	'E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		268.865	
	CIPS=CTB*Z4/	722		and the second seco			and the second	17.924	
., 49	CRCI = C	TB X R						5.377	
	COEM = C	0εM OR CTB*Z5/Z2	/ENYR					0.0	
		2.1.2 FOR DDT&E							DOWN THE STORE OF THE STORE SECTION OF THE SECTION

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.1.17 PRESSURIZED STORAGE MODULE (PSM)

	INPUT F	PARAMETERS	en kalender i de filozofia eta eta eta eta eta eta eta eta eta et		INPUT CO	EFFICIENTS
T= M= CF= PHI= R= DF=	15000.0000 15000.0000 1.000000 0.980000 0.010000 1.000000	TF= 0&M= Z1= Z2= Z3= Z4=	1.00000 0.0 4.00000 60.00000 4.00000 4.00000	CDCI CDE) CICI CIE)	ER =	0.052914 1.000000 0.013734 1.000000
CALCU	LATED VALUES	KG	SUM TO 1.2	.1.1		\$, MILL IONS
CD=CDCER X	(T X DF)XX(CDEX	Y X CF				793.710
CLRM=CICER	X (M)XX(CIEXP)	X CF X TF				206.010
₩ #RM = T / M		managa managa sa ang managa sa managa panggan ay an managa sa				1.000
66 E =1.0 +	LOG(PHI) / LOG(2	2.0)				0.971
CTFU=(CLRM	/ E)X((#RM X Z1+	5)XX(E) -0.	.5XX(E))			805.657
CTB = ((CLR	M/E)X((#RM X Z	23 + 0.5)XX(E	E) -0.5XX(E))) /	′ Z3	201.414
CIPS=CTB*Z	4/22					13.428
CRCI	=CTB X R					2.014
	O&M OR CTB*Z5/Z2	2/ENYR				0.0
COMMENTS						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.2.1 AIRLOCK DOCKING MODULE-ADM

		INPUT P	ARAMETERS			INF	PUT COEF	FICIENTS		
	.	2500.00000	TF=	1.000000		CDC ER=		0.012461		
	M=	2500.00000	=M30	0.0		CDEXP=		1.000000		
	C F=	1.000000	Z 1 =	5.000000		CICER =		0.006036		
	PHI=	0.980000	Z 2=	60.000000	an anger of the server over the	CIEXP=		1.000000		
	R=	0.020000	Z3=	5.000000						
	DF=	1.000000	Z 4=	5.000000	Z5 =		0.0			
	CALCUL	ATED VALUES	KG	SUM TO 1.	2.1.2		na diadana (i.i.). Adaddina artigrifiga diffigirishina	\$,MILL	IONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF					31.152		
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					15.090	•	
Ħ	#RM =T / M						<u> </u>	1.000		
B-167	E = 1.0 +	LOG(PHI) / LOG(2	.01					0.971		e de la companya de l
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				73.413		
	CTB = ((CLRM	4/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3	:	14.683		
	CIPS=CTB*Z4	4/22					The second secon	1.224	. Liver and a second	in Education (Constitution of the Constitution
	CRCI =	=CTB X R					***************************************	0.294		
	= M3D3	O&M OR CT8*Z5/Z2	/ENYR					0.0		
	COMMENTS						الفيلغي 1.4 د البعيد الأران الأدار المعاد			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.2.2 CREW HABITABILITY MODULE-CHM

	INPUT PARAMETERS				INPUT COEFFICIENTS					
	T= M= C:F= P:H:I=	27000.0000 27000.0000 1.000000 0.980000	TF= O6M= Z1= Z2=	1.000000 0.0 17.000000 60.000000		CDCER = CDEXP = CICER = CIEXP =		0.0 0.0 0.003770 1.000000		
	R= DF=	0.020000		17.000000 17.000000			0.0			
	CALCUL	ATED VALUES	KG	SUM TO	1.2.1.2			\$, MILL IONS		
	CD=CDCER X	(T X DF)XX(CDEXF	Y CF				en Konstantin George Seense were	0.0		
	CLRM=CICER	X (M)XX(CIEXP) >	CF X TF					101.790		
ĩ	#RM =T / M							1.000		
168	E = 1.0 + 1	LOG(PHI) / LOG(2	2.0)					0.971		
	CTFU=(CLRM ,	/ E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))			-	1634.456		
	CTB = (CLRM	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		96.144		
	CIPS=CTB*Z4	/22						27.241		
	CRCI =	CTB X R			nian di sanggangan da	The second secon		1.923		
		O&M OR CTB*Z5/Z2	/ENYR					0.0		
	COMMENTS SEE 1.2	.2.2.1 FOR DOTEF					20 100 100 100 100 100 100 100 100 100 1		e en	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.2.3 CONSUMABLES LOGISTICS MODULE-CLM

		INPUT P	ARAMETERS	and the second s		INPL	JT COEFFICIENTS	
· ·	T=	5000.00000	TF=	1.000000		CDCER=	0.0	
	M=	5000.00000	=M3O	0.0		CDEXP=	0.0	4.
	C F=	1.00000	Z 1 =	9.000000		CICER=	0.014000	
	PH I=	0.980000	Z2=	60.000000		CIEXP=	1.000000	
	R=	0.020000	Z 3=	9.000000				
	DF=	1.000000	Z 4=	9.000000	Z 5 =	(0.0	· · · · · · · · · · · · · · · · · · ·
	CALCUL	ATED VALUES	KG	SUM TO	1.2.1.2		\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF				0.0	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				70.000	
ъ	#RM =T / M						1.000	
169	E =1.0 +	LOG(PHI) / LOG(2	.0}			1	0.971	
	CTFU=(CLRM	/ E)X((#RM X Z1+	-5)XX(E) -0	.5XX(E))			604.675	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))		1 / 23	67.186	
	CIPS=CTB*Z4	/72					10.078	
-	CRCI =	CTB X R			······································		1.344	
	CC&M =	OEM OR CTB*Z5/Z2	/ FNYR				0.0	
	COMMENTS SEE 1.2	2.2.2.2 FOR DDT&E						
	والمرابع والمساور وال	en andrewe against the first account of the second	وأباره بالكيالها وهوا الموابدات يواد	e data, and a separation of the separate separate particles and separate se		SPECKAR I SI SEEMERSON ON SPECIAL CONTRACTOR	and the second second second second section in the second section of the second section sectio	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.2.4 SHIELDING

	INPUT P	ARAMETERS			IN	PUT COE	FFICIENTS
T=	11000.0000	TF=	1.000000		CDCER=		0.156000
M≡	11000.0000	=M30	0.0		CDEXP=		1.000000
C F=	1.000000	Z 1 =	8.000000		CICER=		0.101000
PHI=	0.980000	Z 2=	60.000000		CIEXP=		0.355000
R=	0.010000	Z3=	8.000000				
D F=	0.200000	Z 4=	8.000000	Z5 =		0.0	
CALCUL	ATED VALUES	KG	SUM TO	1.2.1.2			\$, MILLIONS
CD=CDCER X	(T X DF)XX(CDEXP) X CF				2.7 2.7 2.8 24 24 14 14 14 14 14 14 14 14 14 14 14 14 14	343.200
CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					2.748
#RM =T / M							1.000
E = 1.0 +	LOG(PHI) / LOG(2	.0)		er en			0.971
CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))				21.160
CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		2.645
CIPS=CTB*Z4	/22			· · · · · · · · · · · · · · · · · · ·			0.353
CRCI =	CTB X R	and summittees on physicians - manual bank - for our bank amount					0.026
= M300	OEM OR CTB*Z5/Z2	/ENYR					0.0
COMMENTS							

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.2.5 CREW SUPPORT MODULE-CSM

		INPUT	PARAMETERS			INPUT COEFFICIENTS					
	T= M= CF= PHI= R=	15000.0000 15000.0000 1.000000 0.980000 0.020000	TF= 0&M= 21= 22= 23=	1.000000 0.0 3.000000 60.000000 3.000000		CDCER= CDEXP= CICER= CIEXP=		0.012432 1.000000 0.005798 1.000000			
	DF=	1.000000	Z 4=	3.000000	Z5 =		0.0				
	CALCUL	ATED VALUES	KG	SUM TO	1.2.1.2			\$, MILL IONS			
	CD=CDCER X	(T X DF)XX(CDEX	P) X CF	en e				186.480			
	CLRM=CICER	X (M)XX(CIEXP)	X CF X TF					86.970			
B-1	#RM =T / M							1.000			
171	E = 1.0 +	LOG(PHI) / LOG(2.0)				iii iga kii i waanaa ii	0.971			
	CTFU=(CLRM	/ E)X((#RM X Z1	+.5)XX(E) -0	.5XX(E))				256.587	· · · · · · · · · · · · · · · · · · ·		
5 55 5 55 5 55	CTB = (CLRM	/E)X((#RM X	Z3 + 0.5)XX(E) -0.5XX(E))) / 23		85.529			
	CIPS=CTB*Z4	/72			المناه المستعدد المست		e e e e e e e e e e e e e e e e e e e	4.276			
	CRCI =	CTB X R		<u> </u>			.	1.711	······································		
	C C & M =	D&M OR CTB*Z5/Z	2/ENYR					0.0			
	COMMENTS										

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.3.1 OPERATIONS, CONSTRUCTION CREW

	INPUT P	ARAMETERS			IN	PUT COEF	FICIENTS	
T= M= CF= PH[=	317.000000 317.000000 1.000000 1.000000	TF= O&M= Z1= Z2=	1.000000 0.0 1.000000 60.000000		CDCER = CDEXP = CICER = CIEXP =		0.0 0.0 0.062400 1.000000	-
R= DF=	0.0 1.000000	Z3= Z4=	31.000000 30.000000	Z5 =	ommer Salessijs	0.0		
CALCUL	ATED VALUES	MEN	SUM TO 1	.2.1.3	myrende) y "myrendenisti film" (<u>manary y p</u> ercentrista in		\$, MILLIONS	
CD=CDCER X	(T X DF)XX(CDEXF	X CF					0.0	
CLRM=CICER	X (M)XX(CIEXP) >	CF X TF					19.781	
#RM =T / M	The second section of the second section of the second section of the second se						1.000	
E =1.0 + 1	_OG(PHI) / LOG(2	.0)					1.000	
CTFU=(CLRM	/ E)X((#RM X Z1+	5)XX(E) -0	.5XX(E))				19.781	
CTB = ((CLRM	/E)X((#RM X 2	(3 + 0.5) XX(E) -0.5XX(E))) / Z3		19.781 .	
CIPS=CTB*Z4	/12						9.890	and the second second
CPCI =	CTB X R						0.0	
= M303	D&M OR CTB*Z5/Z2	PLENTE					0.0	

COMMENTS

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.1.3.2 ORBITAL OPERATIONS, CONST. PROV.

		INPUT P	ARAMETERS		INPUT	COEFFICIENTS	
	.	410832.000	TF=	1.000000	CDCER=	0.0	
	M=	410832.000	=M30	0.0	CDEXP=	0.0	
	CF=	1.000000	Z1 =	1.000000	CICER=	0.000022	
	PHI= R=	1.000000 0.0	Z 2 = Z 3 =	60.000000	CIEXP=	1.000000	المشيونية للكاشية والمالية
	DF=	1.000000	Z3= Z4=	31.000000 30.000000 Z	5 = 0.0		
	CALCUL	ATED VALUES	KG	SUM TO 1.2.1	.3	\$, MILLIONS	***************************************
	CD=CDCER X	(T X DF)XX(CDEXP) X CF			0.0	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF			9.038	
늄	#RM =T / M		· · · · · · · · · · · · · · · · · · ·			1.000	
174	F =1.0 +	LOG(PHI) / LOG(2	.0)			1.000	in and produce a Mangaran.
	CT FU= (CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0	.5XX{E}}		9.038	
	CTB =((CLRM	1/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	9.038	
ý	CIPS=CTB*Z4	+/ Z2				4.519	
}	CRCI =	CTB X R				0.0	
	COEM =	OEM OR CTB*Z5/Z2	/ENYR			0.0	
	COUNTENTS						

1.2.2 LOGISTICS SUPPORT FACILITIES - LEO

This element includes the hardware, software and operations required in LEO to support the construction and operations and maintenance of the satellite system. Included are crew life support facilities, cargo and propellant depots, and vehicle servicing facilities necessary for the receiving and transfer of cargo and personnel distined for a construction base or operational satellite located in GEO.

LEO support operations will require a permanent crew of 24 at the LEO facility. These personnel will provide supervisory activities for transfer of up and down payloads between the HLLV and OTVs. They also perform the scheduled maintenance required by the electric propulsion OTV, such as changeout of ion thruster screens. Included are work and crew support facilities (Table 1.2.2) plus required operations.

SYSTEM Description	ABBREVIATION	WORK SUPPORT FACILITIES	CREW SUPPORT FACILITIES			
CREW HABITABILITY MODULE	СНМ		1			
CONSUMABLES LOGISTICS MODULE	CLM		1			
BASE MANAGEMENT MODULE	вим	1				
CREW SUPPORT MODULE/EVA	CSM/EVA		1			
POWER MODULE	PM	1				

Table 1.2.2 LEO Base Modules

1.2.2.1 WORK SUPPORT FACILITIES

This element includes the facilities and equipment required to provide logistics support in LEO. Included are HLLV and OTV docking stations, payload handling equipment, and cargo and propellant storage depots. Excluded are facilities related to crew support.

A 100 kW solar array power module and the base management module are work support facilities. Cost estimates contained in Tables 1.2.2.1.1 and 1.2.2.1.2 were based on Rockwell Space Station studies.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.2.1.1 BASE MGMT. MODULE-BMM

		INPUT F	PARAMETERS			IN	IPUT COE	FFICIENTS	
	T = M= C F = C + T = C	27000.0000	TF= 0&M= Z1= Z2=	1.000000 0.0 1.000000		CDCER= CDEXP= CICER=		0.091296 1.000000 0.011496 1.000000	
	PHI= R= DF=	0.980000 0.020000 1.000000	Z 2= Z 3= Z 4=	60.000000 1.000000 1.000000		CIEXP=	0.0		
	CALCUL	ATED VALUES	KG	SUM TO	1.2.2.1			\$, MILLIONS	
		<pre>X (M)XX(CIEXP) :</pre>						2464.993 310.392	
₽	#RM = T / M							1.000	
-176	E = 1.0 +	LOG(PHI) / LOG(2	· 0)					0.971	
	CTFU=(CLRM	/ E)X((#RM X Z1	.5)XX(E) -	0.5XX(E))				310.814	
	CTB = ((CLRM	1/E)X((#RM X	23 + 0.5)XX	(E) -0.5XX(E))) / Z3		310.814	
	CIPS=CTB*Z4	1/22					2000 - 100 -	5.180	
رياندسيد دي	CRCI =	CTB X R						6.216	
	CC&M =	O&M OR CTB*Z5/Z	2∕ENYR					0.0	
	COMMENTS								er o en

ROCKWELL SPS CR-2 RÉFERENCE CONFIGURATION TABLE 1.2.2.1.2 POWER MODULE-PM

	INPUT P	ARAMETERS		and the second s	INPUT C	OEFFICIENTS	o postar i marcino de la m
T= M= C F= PHT=	250.000000 250.000000 1.000000	TF= 0&M= Z1= Z2=	1.000000 0.0 1.000000		CDCER= CDEXP= CICER=	1.40000 1.000000 1.100000	
R= DF=	0.980000 0.020000 1.000000	Z3= Z4=	1.000000 1.000000	Z5 =	CIEXP= 0.0	1.000000	
CD=CDCER X (ATED VALUES (T X DF)XX(CDEXP K (M)XX(CIEXP) X		SUM TO	1.2.2.1		\$,MILLIONS 350.000 275.000	
#RM =T / M	.OG(PHI) / LOG(2	.0)				1.000 0.971	
CTFU=(CLRM /	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))			275.373	
	/E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3	275.373	
CIPS=CTB*Z4/ CRCI = 0	ZZZ CTB X R					4.590 5.507	
CC&M = C	D&M OR CTB*Z5/Z2	/ENYR				0.0	

1.2.2.2 CREW SUPPORT FACILITIES

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, recreation facilities, and health facilities at LEO.

The crew habitability module and crew support module/EVA are the same basic configuration as for those on the SCB. However, the crew support module has an airlock and EVA preparation area. A consumables logistics module is the third element of crew support facilities.

CERs used for crew support facilities were based upon Rockwell Space Station studies. See Tables 1.2.2.2.1, 1.2.2.2.2, and 1.2.2.2.3.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.2.2.1 CREW HABITABILITY MODULE-CHM

		INPUT P	ARAMETERS			INPUT C	DEFFICIENTS	
. 	T= M=	27000.0000 27000.0000	TF= O&M=	1.000000	C	DC ER = DEXP =	0.009714 1.000000	
	CF= PHI= R=	0.980000	Z1= Z2= Z3=	1.000000		ICER= IEXP=	0.003770 1.000000	क्षां हारूनावेशको । हुन कुन्नारकोण कार स्थानका <mark>व्यक्त</mark> रह स्के
	DF=	0.020000 1.000000	23= 24=	1.000000	Z5 =	0.0		
	CALCUL	ATED VALUES	KG	SUM TO 1	.2.2.2		\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF		and the same and same		262.278	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				101.790	
B-1	#RM =T / M						1.000	
.79	E =1.0 +	LOG(PHI) / LOG(2	.0)				0.971	والمتاه فيستهواني
gan, a dead for the gament	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))			101.928	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	101.928	
	CIPS=CTB*Z4	/22				A rming Market Market Baggara	1.699	
	CRCI =	CTB X R					2.039	
	COEM =	O&M OR CT8*Z5/Z2	/ENYR				0.0	
	어떻게 되었다. 그 하는 사람	di kacamin mengangan di Berangan	er aller er er egerger af f					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.2.2.2 CONSUMABLES LOGISTICS MODULE

		INPUT P	ARAMETERS			INPUT C	OEFFICIENTS	
	T=	5000.00000	TF=	1.000000	CDCE		0.053000	
	M= CF=	5000.00000 1.000000	0&M= Z1=	0.0	CDEX	1	1.000000 0.014000	
	PHI=	0.980000	Z 2=	60.000000	CIEX		1.000000	
	R=	0.020000	Z3=	1.000000	The same that the same control of the same to the same			The second of th
	DF=	1.000000	Z4=	1.000000	Z5 =	0.0		
	CALCUL	ATED VALUES	KG	SUM TO	1.2.2.2		\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF				265.000	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				70.000	
1	#RM =T / M						1.000	
180	E = 1.0 +	LOG(PHI) / LOG(2	• 0)				0.971	
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E)}			70.095	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX	((E) -0.5XX(E)))	′ Z3	70.095	
	CIPS=CTB*Z4	-/22					1.168	
	CRCI =	CTB X R					1.402	
	CO&M =	O&M OR CTB*Z5/Z2	/ENYR				0.0	
	COMMENTS							

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.2.3 CREW SUPPORT MODULE/EVA

	INPUT P	ARAMETERS		INPUT	CDEFFICIENTS	
	27000.0000	TF=	1.000000	CDCER=	0.012432	
M=	27000.0000	=M30	0.0	CDEXP=	1.000000	
C F=	1.00000	Z1=	1.000000	CICER=	0.005798	
PHI=	0.980000	Z 2=	60.000000	CIEXP=	1.000000	
R=	0.020000	Z 3=	1.000000			
DF=	1.000000	Z4=	1.000000	25= 0.		
CAI	LCULATED VALUES	KG	SUM TO J. • 2	.2.2	\$, MILLIONS	waswa
CD=CDCEI	R X (T X DF)XX(CDEXP) X CF			335.664	
CLRM=CI	CER X (M)XX(CIEXP) X	CF X TF			156.546	•
₩ #RM = T .	/ M				1.000	
 ₩ ₽ E =1.(0 + LOG(PHI) / LOG(2	.0)			0.971	-1
CT FU= (.CI	LRM / E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))		156.759	
CTB = ((CLRM/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	156.759	
CIPS=CT	B*Z4/Z2				2.613	***************************************
CRC	I =CTB X R				3.135	
C C&I	M = 0&M OR CTB*Z5/Z2	/FNYR			0.0	
COMMENTS					and the second of the second o	2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 -



1.2.2.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the logistics support facility. It includes both the direct and support personnel and the expendable maintenance supplies required for logistics support.

An average of 24 crew members are required at the LEO Base to support orbital operations. Engineering estimates were made of the operations and consumable requirements at LEO. See Tables 1.2.2.3.1 and 1.2.2.3.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1-2-2-3-1 LEO OPERATIONS CREW

	INPUT PARAMETERS	I NPUT CO	EFFICIENTS	
	T= 24.000000 TF= 1.000000	CDCER=	0.0	
	M= 24.000000 0&M= 0.0	CDEXP=	0.0	——————————————————————————————————————
	CF= 1.000000 Z1= 1.000000	CICER=	0.062400	
	PHI= 1.000000 Z2= 60.000000	CIEXP=	1.000000	
	R= 0.0 Z3= 31.000000		ere	read and appropriate free in the second
	DF= 1.000000 Z4= 30.000000	25 = 0.0		
	선택님 하는 경기 이번 보고를 하는 것 같아. 그런 그런 그런 그는 그 그 그는 그를 다 되었다.			
	CALCULATED VALUES MEN SUM TO	1.2.2.3	\$,MILLIONS	
	CD=CDCER X (T X DF)XX(CDEXP) X CF	e de la composition br>La composition de la br>La composition de la	0.0	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF		1.498	
β	#RM = T / M		1.000	
183	E =1.0 + LOG(PHI) / LOG(2.0)		1.000	The state of the s
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))		1.498	
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	1.498	
1	CIPS=CTB*Z4/Z2		0.749	الرمشية فحالتها
	CRCI: = CTB: X R		0.0	
			<u> </u>	
	COEM = DEM OR CTB*Z5/Z2/ENYR		0.0	
	COMMENTS			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.2.3.2 LEO CREW PROVISIONS

		INPUT P	ARAMETERS			IN	PUT COEF	FICIENTS	
	T= M= CF= PHI= R= DF=	31104.0000 31104.0000 1.000000 0.0 1.000000	TF= O&M= Z1= Z2= Z3= Z4=	1.000000 0.0 1.000000 60.000000 31.000000 30.000000	Z5 =	CDCER= CDEXP= CICER= CIEXP=	0.0	0.0 0.0 0.000022 1.000000	
		LATED VALUES	KG	SUM TO 1.	.2.2.3			\$, MILL IONS	name plak tim (propositione directly 1-1); biolishin a releaseme
٠.		X (M)XX(CIEXP) X						0.0 0.684	
<u>~</u>	#RM =T / M E =1.0 +	LOG(PHI) / LOG(2	•0)					1.000	
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0.	.5XX(E))				0.684	14: - a minimus para sara saman mananda mana
	CTB = ((CLRN	M/E)X((#RM X Z	3 + 0.5)XX(E	E) -0.5XX(E))) / Z3		0.684	
	CIPS=CTB*Z4	4/Z2						0.342	
	and any or the state of the sta	=CTB X R	/FALVO					0.0	
	COMMENTS	O&M OR CTB*Z5/Z2	VENTE						

1.2.3 SATELLITE O&M SUPPORT FACILITIES

This element includes the facilities, equipment, and operations required in GEO to support the operations and maintenance of the satellite system. Included are the on-orbit monitor and control facility and the life support facilities and equipment required to provide confortable safe living quarters for the resident crew members.

A permanent satellite operations and maintenance base is installed on each satellite at a location near the antenna to provide best access to all systems of the satellite. The base has facilities for both the crew and for storage of maintenance material, and installation/repair equipment. Table 1.2.3 identifies the supporting facilities.

SYSTEM . DESCRIPTION	ABBREVIATION	WORK SUPPORT FACILITIES	CREW SUPPORT FACILITIES
AIRLOCK DOCKING MODULE	ADM	3	1
CREW HABITABILITY MODULE	сни		1.
CONSUMABLES LOGISTICS MODULE	CLM		1 ga 1 a
BASE MANAGEMENT MODULE	вим	1	
CREW SUPPORT MODULE/EVA	CSM/EVA		1
PRESSURIZED STORAGE MODULE	PSM	2	

Table 1.2.3 Satellite O&M Base

1.2.3.1 WORK SUPPORT FACILITIES

This element includes the facilities and equipment required for operation and maintenance of the satellite system. Included are satellite monitor and control stations and any centralized repair facilities not included under maintenance.

The ADM is required at four places for the integration of other modules comprising the satellite O&M base. Three of these modules are to be used primarily for work support operations. The satellite BMM incorporates a monitoring and fault isolation capability for the SPS satellite subsystems as well as the controls required for alternate operational modes and functional isolation of selected subsystems for maintenance. The cost estimates of these modules and the PSM are shown in Tables 1.2.3.1.1, 1.2.3.1.2 and 1.2.3.1.3. The CERs are based on Rockwell Space Station studies.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.1.1 AIRLOCK DOCKING MODULE-ADM

	INPUT F	ARAMETERS			IN	PUT COEFFIC	CIENTS	
T= M= CF= PHI=	2500.00000 2500.00000 1.000000 0.980000	TF= 0&M= Z1= Z2=	1.000000 0.0 3.000000 60.000000		CDCER= CDEX®= CICER= CIEXP=	0 . 0 .	.0 .006036 .00000	
R= DF=	0.020000 1.000000	Z3= Z4=	180.000000	25 =	Olex.	0.0		
CALCUL	ATED VALUES	KG	SUM TO	1.2.3.1	· · · · · · · · · · · · · · · · · · ·		\$, MILLIONS	
CD=CDCER X	(T X DF)XX(CDEX	Y) X CF					0.0	
CLRM=CICER	X (M)XX(CIEXP)	CF X TF					15.090	
#RM =T / M		and A and the case of the case				. The same of the	1.000	n de nagh de naghair ean leite spirit y still de sgeladen still littles.
E = 1.0 +	LOG(PHI) / LOG(2.0)					0.971	
CTFU=(CLRM	/ E)X((#RM X Z1-	+.5)XX(E) -0	.5XX(E))				44.520	any paolani ki najamaninana paonanjyai ki ndan
CTB = ((CLRM	/E)X((#RM X	23 + 0.5)XX(E) -0.5XX(E))) / Z3		13.352	
CIPS=CTB*Z4	/22						40.056	
CRCI =	CTB X R	ر در				andria - on annual programme of the State of	0.267	my yaki in ayahingangangan in akuma ti inggangan da
C O & M =	OEM OR CTB*Z5/Z	2/ENYR					0.0	
COMMENTS SEF 1.2	2.1.2.1 FOR DDT&							

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.1.2 BASE MGMT MODULE-BMM

ina dege i kantina ada Tangka kantang	INPUT P	ARAMETERS		INPUT	COEFFICIENTS	
T= M= CF= PHI=	27000.0000 27000.0000 1.000000 0.980000	TF= O&M= Z1= Z2=	1.00000 0.0 1.000000 60.000000	CDCER = CDEXP = CICER = CIEXP =	0.0 0.0 0.011496 1.000000	
R= DF=	0.020000 1.000000	Z3= Z4=	60.000000	Z5 = 0.0		
CALCU	LATED VALUES	KG	SUM TO 1.2	2.3.1	\$, MILLIONS	
CD=CDCER X	(T X DF)XX(CDEXP) X CF			0.0	
CLRM=CICER	X (M)XX(CIEXP) X	CF X TF			310.392	
ы #RM =T / M	*4				1.000	
8 E = 1.0 +	LOG(PHI) / LOG(2	.0)			0.971	
CTFU=(CLRM	/ E) X((#RM X Z1+	.5)XX(E) -0	.5XX(E))		310.814	
CTB = ((CLR	M/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	283.323	
CIPS=CTB*Z	4/72				283.322	
CRCI	=CTB X R				5.666	
COEM =	OEM OR CTB*Z5/Z2	/ ENYR			0.0	
COMMENTS SEE 1.	2.2.1.1 FOR DDT&F					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.1.3 PRESSURIZED STORAGE MODULE-PSM

	INPUT PARAMETERS		INPUT CO	DEFFICIENTS	
T= M= CF= PHI= R= DF=	15000.0000 TF= 15000.0000 0&M= 1.000000 Z1= 0.980000 Z2= 0.010000 Z3= 1.000000 Z4=	1.000000 0.0 2.000000 60.000000 120.000000	CDCER= CDEXP= CICER= CIEXP= 5= 0.0	0.0 0.0 0.013734 1.000000	
CALCU	LATED VALUES KG	SUM TO 1.2.3	.1	\$,MILLIONS	
	(T X DF)XX(CDEXP) X CF X (M)XX(CIEXP) X CF X TF			0.0 206.010	
E =1.0 +	LOG(PHI) / LOG(2.0)			0.971	
CTFU={CLRM	/ E)X((#RM X Z1+.5)XX(E) -	0.5XX(E))		408.244	
	M/E)X((#RM X Z3 + 0.5)XX	(E) -0.5XX(E))) / Z3	184.403	
CIPS=CTB*Z	4/Z2			368.805	
CRCI	=CTB X R			1.844	
COMMENTS	O&M OR CTB*Z5/Z2/ENYR 2.1.1.17 FOR DDT&E			0.0	

1.2.3.2 CREW SUPPORT FACILITIES

This element includes the facilities and equipment required for the life support and well-being of the crew members. Included are living quarters, recreation facilities, and health facilities.

The combination crew support and EVA module (CSM/EVA) has the same internal function as for the SCB, but occupies only half of the module. The other half is an integrated multi-crew member EVA preparation area and airlock station.

The ADM, CHM, CLM and CSM/EVA modules are costed in Tables 1.2.3.2.1, 1.2.3.2.2, 1.2.3.2.3, and 1.2.3.2.4. The estimates are based on Rockwell's Space Station studies.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.2.1 ATRLOCK DOCKING MODULE-ADM

IABLE	1.2.3.2.1 AIR	LUCK DUCKT	NG MUDULE-AUM		방문화 사람들은 하시아들이 보는 이 없다.	
	INPUT P	ARAMETERS		T N	PUT COEFFICIENTS	
	2500.00000	TF=	1.000000	CDCFR=	0.0	
M=	2500.00000	= M3 O	0.0	CDEXP=	0.0	
CF≔	1.000000	Z 1 =	1.000000	CICER=	0.006036	,
PH [=	0.980000	Z 2=	60.000000	CIEXP=	1.000000	
R=	0.020000	Z3=	60.000000			
DF=	1.000000	Z4=	60.000000	Z5 =		
CALCULA	ATED VALUES	KG	SUM TO 1	.2.3.2	\$, MILLIONS	
CD=CDCER X (T X DF;XX(CDEXP) X CF				
CLRM=CICER)	((M)XX(CIEXP) X	CF X TF			/	
#RM =T / M		والمتعادية			1.000	
E =1.0 + L	.OG(PHI) / LOG(2	• 0)			0.971	
CTFU=(CLRM /	' E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))		15.111	
CTB = ((CLRM)	'E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3	13.774	
CIPS=CTB*Z4/	1 72		grande de la companya		13.774	:
CRCI = 0	TB X R				0.275	
C C & M = 0	DEM OR CTB*Z5/Z2	/ENYR				
COMMENTS SEE 1.2.	.1.2.1 FOR DDT&E					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.2.2 CREW HABITABILITY MODULE-CHM

INPUT PARAMETERS		INPUT COEFFIC	I ENT S
T= 27000.0000 TF= M= 27000.0000 D&M= CF= 1.000000 Z1= PHI= 0.980000 Z2= R= 0.020000 Z3= DF= 1.000000 Z4=		CIEXP= 1.	
CALCULATED VALUES KG CD=CDCER X (T X DF)XX(CDEXP) X CF	SUM TO 1.2.3.2		\$,MILLIONS 0.0
CLRM=CICER X (M)XX(CIEXP) X CF X TF			101.790
#RM =T / M B			1.000 0.971
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5X)	X(E))		101.928
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -	-0.5XX(E))	1 / 23	92.913
CIPS=CTB*Z4/Z2			92.913
CRCI =CTB X R			1.858
CC&M = O&M OR CTB*Z5/Z2/FNYR			0.0
COMMENTS SEE 1.2.2.2.1 FOR DDT&E			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.2.3 CONSUMABLES LOGISTICS MODULE-CLM

	INPUT	PARAMETERS			INPUT CO	EFFICIENTS	and the second
T= M= C F= PH I= R= DF=	5000.00000 5000.00000 1.000000 0.980000 0.020000 1.000000	TF= 06M= Z1= Z2= Z3= Z4=	1.00000 0.0 1.000000 60.000000 60.000000 60.000000	CDCER CDEXP CICER CIEXP	=	0.0 0.0 0.014000 1.000000	
CALCUL	ATED VALUES	KG	SUM TO 1	.2.3.2		\$,MILLIONS	
CD=CDCER X	(T X DF)XX(CDEX	P) X CF				0.0	
CLRM=CICER	X (M)XX(CIEXP)	X CF X TF				70.000	
#RM =T / M						1.000	
E = 1.0 +	LOG(PHI) / LOG(2.0)				0.971	
CTFU=(CLRM	/ E)X((#RM X Z1	+.5)XX(E) -0.	.5XX(E))			70.095	
CTB = ((CLRM	/E)X((#RM X	Z3 + 0.5)XX(E	-0.5XX(E))		Z3	63.895	Diversity of the contract of t
CIPS=CTB*Z4	/22					63.895	
CRCI =	CTB X R	tagi saka sa				1.278	
CCEM =	N&M OR CTB*Z5/Z	2/ENYR				0.0	
COMMENTS SEE 1.2	-2-2-2 FOR DOTE						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.2.4 CREW SUPPORT MODULE/EVA

INPUT PARAMETERS	. To state the managed and only a second	INPUT COL	EFFICIENTS
M= 27000.0000	000000 0 000000 000000 000000 000000 Z5=	CDCER = CDEXP = CICER = CIEXP =	0.0 0.0 0.005798 1.000000
CALCULATED VALUES KG SI	UM TO 1.2.3.2		\$, MILLIONS
CD=CDCER_X (T X DF)XX(CDEXP) X CF			
CLRM=CICER X (M)XX(CIEXP) X CF X TF			156.546
#RM =T / M			1.000
E = 1.0 + LOG(PHI) / LOG(2.0)			0.971
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E)			156.759
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5)	XX(E))) / Z3	142.894
CIPS=CTB*Z4/Z2			142.894
CRCI =CTB X R			2.858
CC&M = O&M OR CTB*Z5/Z2/ENYR			0.0
COMMENTS SEF 1.2.2.3 FOR DDT&E			

1.2.3.3 OPERATIONS

This element includes the planning, development, and conduct of operations at the O&M support facility. It includes both the direct and support personnel and the expendable maintenance supplies required in GEO for satellite operations and maintenance.

The satellite operations base crew is manned by 30 persons on a continuous basis throughout the year. This crew and supporting provisions are costed in Tables 1.2.3.3.1 and 1.2.3.3.2 based on engineering estimates.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.3.1 SATELLITE OPERATIONS CREW

COMMENTS

	INPUT P	ARAMETERS			IN	PUT COEFFICIENTS		
T =	30.000000	TF=	1.000000		CDCER=	0.0		
M=	30.000000	=M30	0.0		CDEXP=	0 • 0		
CF=	1.000000	Z 1 =	1.000000		CICER=	0.062400		
PHI=	1.000000	Z 2=	60.000000		CIEXP=	1.000000		
R=	0.0	Z3=	60.000000					
DF=	1.000000	Z 4=	60.000000	Z5 =	•	0.0 200 0.00		
CALCULA	TED VALUES	MEN	SUM TO	1.2.3.3		\$•	MILLIONS	
CD=CDCER X (T X DF)XX(CDEXP) X CF				0	• 0	
CLRM=CICER X	(M)XX(CIEXP) X	CF X TF					.872	
#RM =T / M		- The transfer of the transfe				1.000	mga nari di ina jama di dani sampi di dama di Admini, saya di dama	
E = 1.0 + L	OG(PHI) / LOG(2	.0)				1.000		e e benede e e e e e e e e e e e e e e e e e
CTFU=(CLRM /	E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	.872	
CTB = ((CLRM/	E)X((#RM X Z	3 + 0.5) XX(E) -0.5XX(E))) / 23		.872	
CIPS=CTB*Z4/	72 · · · · · · · · · · · · · · · · · · ·					1	.872	10 (M)
CRCI =C	TB X R				ب استان المساور	<u> </u>	•0	والمراجعة والمراجعة والمراجعة
CC&M = 0	&M OR CTB*Z5/Z2	/ENYR				0	•0	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.2.3.3.2 SATELLITE CREW PROVISIONS

	INPUT P	ARAMETERS			IN	PUT COEF	FICIENTS	
T=	38880.0000	TF=	1.000000		CDCER =		0.0	
M=	38880.0000	=M3O	0.0		CDEXP=		0.0	
CF=	1.000000	Z1= .	1.000000		CICER=		0.000022	
PHI=	1.000000	Z 2=	60.000000		CIEXP=		1.000000	
R≡	0.0	Z3=	60.000000					
DF=	1.000000	Z 4=	60.000000	Z5 =		0.0		
CALCUL	ATED VALUES	KG	SUM TO	1.2.3.3			\$, MILLIONS	, mente giud, sant sant se mine, signi mententi interne se de la d
CD=CDCER X	(T X DF)XX(CDEXP) X CF					0.0	
CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					0.855	
#RM =T / M		naga, giba shiring dang againny at man maning a amang a ngint and isa a sa an			.,		1.000	aprilimento de la granda de aprilimenta qualificación de aprilimento de aprilimen
E =1.0 +	LOG(PHI) / LOG(2	.0)					1.000	
CTFU= (CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))				0.855	
CTB = (CLRM	1/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		0.855	
CIPS=CTB*Z4	4/72					1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0.855	
CRCT =	CTB X R			to appear to the second		and the state of t	0.0	professor () days days of a support day opportunity to the same of the same o
CCEM =	DEM OR CTB*Z5/Z2	/ENYR					0.0	

COMMENTS

1.3 TRANSPORTATION

This element of the costing includes all space transportation required to support the satellite system assembly and operation. Included are transportation requirements supporting the precursor activity, launch to LEO, orbit-to-orbit transfer of all hardware, materials, and personnel, and intra-orbit movement of cargo during the construction and lifetime operation of the satellite system.

The overall scenario for SPS space transportation systems consists of seven major elements — Space Shuttle derivatives for personnel (PLV) and precursor cargo (STS-HLLV); SPS heavy lift launch vehicle (HLLV); electric orbit transfer vehicle (EOTV); intra-orbit transfer vehicle (IOTV); personnel orbit transfer vehicle (POTV); personnel module (PM); and orbital/ground support facilities. Transportation requirements and concepts for SPS vary as a function of program phase. During the verification planning period (1981 — 1987), the baseline Shuttle is used to conduct sortic missions. Later in the verification program "growth" Shuttle is used to deliver personnel and cargo to LEO. The Shuttle derived HLLV is also employed early in the program for LEO fabrication of the space construction base plus support in building the precursor satellite (EOTV) test model. Figure 1.3-1 illustrates early program systems and identifies the SPS VTO/HL HLLV that will be needed for the fabrication of flight EOTVs and the mass-to-orbit requirements of satellite construction.

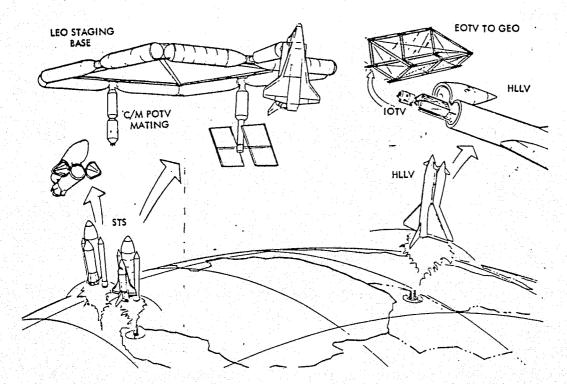


Figure 1.3-1. SPS Transportation System - LEO Operations Operational Program

Geosynchronous orbit is the eventual destination of SPS construction materials/equipment, personnel, and supplies. The crews will be transported from earth to LEO by the growth Shuttle containing the personnel module (PM) where the PM will then be carried to GEO by the POTV. Cargo will be delivered to LEO by the SPS VTO/HL-HLLV configuration, transferred to the EOTV by IOTV's, transported to GEO by the EOTV, and off-loaded by IOTV's. Additional detail on the individual vehicles is presented in later subsections.

Mass-to-orbit requirements for construction, propellant, and operations/maintenance activities were established in accordance with the mission profile and build schedule of two SPS satellites per year with a first unit (TFU) by the end of year 2000. These calculations were based on a round trip vehicle life as shown in Table 1.3-1.

Table 1.3-1. Vehicle Life with Maintenance

	VEHICLE			R.T.	FLIGHT	S PER	VEHIC	CLE
STS GROWTH	VEHICLE FOR	PLV/CARGO				100		
SPS-VTO/HL	HEAVY LIFT !	AUNCH VEHICLE				300		
EOTV-CARGO	(ELECTRIC) (RBIT TRANSFER	VEH.			20		
POTV-PERSON	NNEL ORBIT TI	RANSFER VEHICL	E			100		
IOTV-INTRO	ORBIT TRANS	FER VEHICLE				200		

Table 1.3-2 shows the vehicle fleet and vehicle flight requirements to build the first SPS satellite, LEO construction base, and the EOTV test vehicle. These calculations were based on the mass-to-LEO and GEO for personnel, materials, and supplies identified to each of the transportation modes. Precursor activities can be completed by utilizing (1) the two existing TFU personnel modules (PMs); and (2) an additional PLV over the two needed for the TFU. Two Shuttle launch vehicle sets will be combined with a cargo container/engine module to transport materials to LEO for the precursor activity. TFU vehicle requirements are based on mission timelines, turnaround schedules, and flight profiles.

Table 1.3-3 tabulates the total program transportation requirements and the number of flights per vehicle as needed to construct the satellites and to provide operations and maintenance after IOC. These calculations are the basis for developing overall fleet requirements for a 60-unit SPS program, but do not include the precursor effort identified in Table 1.3-2 nor the additional vehicles needed for attrition/spares or overhaul (replacement capital investment).



Table 1.3-2. TFU Transportation Requirements

	MASS x	10 ⁶ KG		<u> </u>	EHICLE	FLIGHTS		
			PLV	HLLV	POTV	EOTV	10	ſV
	LE0	GE0					LEO.	GE0
SATELLITE CONST. MAINT. & PACKAGING	37.12	37.12	45	163.5	45	6.5	164	164
CREW CONSUMABLES & PKG.	0.98	0.94	-	4.3	-	0.2	. 4	4
POTV PROPELLANTS & PKG.	2.91	1.46	-	12.8	-	0.3	13	. 6
EOTV CONST., MAINT, & PKG.	7.20	-	15	31.7	-	-	32	-
EOTV PROPELLANTS & PKG.	4,79	-	-	21.1		- :	21	-
IOTY PROPELLANTS & PKG.	0.13	0.06	-	0.6	-	-	. 1	-
			·	1			235	174
TOTAL	53.13	39.58	60	234.0	45	7.0	41	09
TFU FLEET VEHICLE REQUIREME	TFU FLEET VEHICLE REQUIREMENTS			5	4	6		4
GROWTH SHUTTLE VEHICLE/OPERATIONS REQUIREMENTS FOR PRECURSOR ACTIVITIES (LEO BASE, SPACE CONSTRUCTION BASE, AND			72 FLIGHTS 1 VEHICLE			129 FLIGHTS 2 VEHICLES		
EOTV TEST VEHICLE - EOTV'S)			PE	RSONNEL	(PLV)	CARGO CARRIER/ENGINE MODULE AND LAUNCH VEHICLE		

Table 1.3-3. Total Program Transportation Requirements

	MASS x	10 ⁶ KG		v	EHICLE I	FLIGHTS		
			PLV	HLLV	POTV	EOTV	I	OTV
	LEO	GEO					LEO	GEO
SATELLITE CONSTRUCTION OPERATIONS & MAINTENANCE	2197.8 1803.0	2197.8 1803.0	1340 3694	9682 7943	1220 3660	425.1 348.7	9682 7943	9682 7943
CREW CONSUMABLES CONSTRUCTION OPERATIONS & MAINTENANCE	31.5 86.8	28.7 86.0	<u>-</u>	139 382	-	5.6 16.6	139 382	126 379
POTV PROPELLANTS CONSTRUCTION OPERATIONS & MAINTENANCE	82.7 267.8	41.4 133.8	<u>-</u>	364 1180	-	8.0 25.9	364 1180	182 589
EOTV CONSTRUCTION CONSTRUCTION OPERATIONS & MAINTENANCE	28.2 22.2	24.2 19.0	- ·	124 98	-	4.7 3.7	124 98	107 84
EOTY PROPELLANTS CONSTRUCTION OPERATIONS & MAINTENANCE	340.3 304.0	2.0 -		1499 1339	-	0.4	1499 1339	9
IOTV PROPELLANTS CONSTRUCTION OPERATIONS & MAINTENANCE	7.2 6.6	3.3 3.0	_	32 29	-	0.6 0.6	32 29	15 13
SUMMARY CONSTRUCTION OPERATIONS & MAINTENANCE	2687.7 2490.4	2297.4 2044.8	1340 3694	11,840 10,971	1220 3660	444 396	11,840 10,971	10,121 9,008
TOTAL	5178.1	4342.2	5034	22,811	4880	840	22,811	19129
VEHICLE FLEET CONSTRUCTION OPERATIONS & MAINTENANCE		_	14 37	39 37	12 37	22 20		10
TOTAL	-	-	51	76	49	42	2	10

1.3.1 SPS HEAVY LIFT LAUNCH VEHICLE (HLLV)

The SPS HLLV is shown in Figure 1.3-2 and has a payload capability of 227,000 kg with a vertical take-off and horizontal landing feature. The SPS HLLV is used to bring space construction and support equipment payloads, satellite system hardware, OTVs, consumables and crew expendables, and propellants from earth to LEO. This element covers the SPS HLLV vehicles and operations required to support the satellite system assembly and operation during a 30 year life. Ground rules and guidelines applicable to the HLLV are summarized in Table 1.3-4.

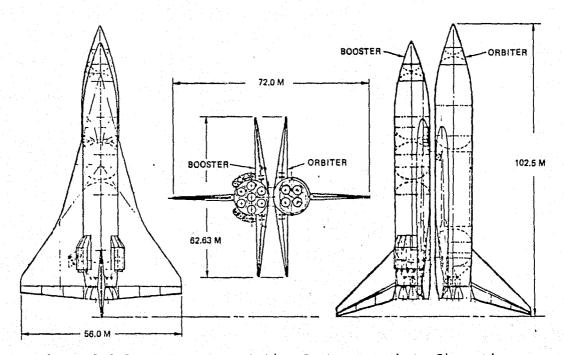


Figure 1.3-2. SPS Transportation System Launch Configuration

Table 1.3-4. HLLV Ground Rules/Assumptions

TWO-STAGE VERTICAL TAKEOFF/HORIZONTAL LANDING (VTO/HL)

FLY BACK CAPABILITY BOTH STAGES - ABES FIRST STAGE ONLY

PARALLEL BURN WITH PROPELLANT CROSSFEED

LOX/RP FIRST STAGE - LOX/LH2 SECOND STAGE

HI Pc GAS GENERATOR CYCLE ENGINE - FIRST STAGE [1s (VAC) = 352 SEC.]

HI Pc STAGED COMBUSTION ENGINE - SECOND STAGE [1s (VAC) = 466 SEC.]

STAGING VELOCITY - HEAT SINK BOOSTER COMPATIBLE

CIRCA 1990 TECHNOLOGY BASE - BAC/MMC WEIGHT REDUCTION DATA

ORBITAL PARAMETERS - 487 KM @ 31.6°

PAYLOAD CAPABILITY - 227×10³ KG UP/45 KG DOWN

THRUST/WEIGHT - 1.30 LIFTOFF/3.0 MAX

15% WEIGHT GROWTH ALLOWANCE/0.75% AV MARGIN



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1.3.1.1 SPS HLLV FLEET

A total of 76 HLLV vehicles are required to handle the mass flow requirements throughout the 60 year SPS program. Thirty-nine vehicles are required for the construction of 60 satellites and 37 vehicles are needed for operation and maintenance during the 30 year satellite lifetime.

Data used in projecting estimates for the HLLV and supporting flight costs were factored from the NASA/JSC contract NAS9-15196. Specific changes were made to consider the reference HLLV design configuration; vehicle complexity factors — engines, ablative shield, propellant valves, and system/subsystem design; plus the greater mass of the Orbiter/booster as compared with current experience and Rockwell Space Shuttle contract work.

HLLV capital asset replacements, major overhaul requirements, spares provisioning, and system lifetimes were projected as being equivalent to two vehicle replacements for each of the SPS fleet vehicles. These calculations are reflected as an annual cost per satellite over the 30 year period.

The DDT&E cost estimate was developed from a careful evaluation of the NAS9-15196 data base and a comparative factoring of these data as compared with data directly applicable to the Space Shuttle program.

See Table 1.3.1.1 for the SPS HLLV cost computer program tabulation.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.1.1 SPS-HLLV FLEET

B-202

	INPUT PARAMETE	ERS S	INPUT	COEFFICIENTS	
T=	1.000000 TF= 1.000000 OEM=	1.000000	CDCER= CDEXP=	8600.00000 1.000000	
C F=	1.000000 Z1=	5.000000		2000.00000	
PHI=	0.920000 Z2=	60.000000	CIEXP=	1.000000	
R=	0.084440 Z3=	228.000000			
DF=	1.000000 Z4=	39.000000	Z5= 37.	00000	
CALCULAT	ED VALUES SET	SUM TO 1	.3.1	\$, MILLIONS	- Part - Task (In-alling), a 1997 - 1997 - Task (IN-Additional) - 1997
CD=CDCFR X (T	X DF)XX(CDEXP) X CF			8600.000	
CLRM=CICER X	(M)XX(CIEXP) X CF X			2000.000	
#RM = T / M				1.000	
#K(1 - 1 / 14				1.000 m	
E = 1.0 + L0	G(PHI) / LOG(2.0)			0.880	egiste e e estado e e e e e e e e e e e e e e e e e e e
CTFU=(CLRM /	E)X((#RM X Z1+.5)XX(E) -0.5XX(E))		8950.176	
					na managanan arawan kanan na managan na mana
CTB = ((CLRM/E)X((#RM X Z3 + 0.5	5)XX(E) -0.5XX(E))	1 / Z3	1180.031	
CIPS=CTB*Z4/Z	. 2			767.020	
	and the second of the second o				
CRCI =CT	B X R		and the state of t	99.642	
30 = M303	M OR CTB*Z5/Z2/ENYR			24.256	
COMMENTS					

1.3.1.2 SPS HLLV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS program. The HLLV has a lifetime capability of 300 flights.

There are a total of 22.811 round trip flights required to support the 60 year program where approximately 227,000 kg is delivered per flight. These are grouped into a total of 11840 flights for construction and 10,971 flights for operations and maintenance. The TFU requires a total of 234 flights to carry the necessary mass to orbit. On the average of 60 satellites, approximately 197 flights are needed for satellite construction and 6 flights are required for annual operations and maintenance per satellite.

The projected cost per HLLV flight is based on contract data (reference NAS9-15196) that was factored and revised to arrive at a propellant, payload integration, and supporting operational cost by evaluation against such things as propellant costs versus HLLV requirements. See Table 1.3.1.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.1.2 SPS-HLLV OPERATIONS

CC&M = O&M OR CTB*Z5/Z2/ENYR

COMMENTS

	INPUT F	PARAMETERS			INPUT COE	FFICIENTS	
T= 1	1.000000	TF=	1.000000		CDCER=	0.0	
M=	1.000000	=M3O	0.0		CDEXP=	0.0	
CF=		- ·	234.000000		CICER=	2.480000	
PHI=	Annual Control of the	Z 2=	60.000000	وأأنب بسنأ يظلان بالمسا	CI EXP=	1.000000	
P=	0.0		22811.0000		10071 0000		
DF≡	1.000000	Z 4=	11840.0000	25 =	10971.0000		
CALCULATE	D VALUES	FLIGHT	SUM TO	1.3.1	- Maringan and Lander of the Land Spanish members of the Lander Spanish College	\$,MILLIONS	
CD=CDCER X (T	X DF) X X (CD E X F) X CF				0.0	
CLRM=CICER X (M)XX(CIEXP)	K CF X TF				2.480	
#RM =T / M	and the state of t	apparatuates. As one is not a responsibilities on the architecture.				1.000	
E = 1.0 + LOG	(PHI) / LOG(2	2.01				1.000	
CTFU=(CLRM / E)X((#RM X Z14	5)XX(E) -	0.5XX(E))			580.320	
CTB =((CLRM/E)	X((#RM X - 3	3 + 0.5)XX	(E) -0.5XX(E))	real and in the second of the) / Z3	2.480	
CIPS=CTB*Z4/Z2						489.387	
CRÇI =CTB	X R					0.0	* ··········

15.116

ORIGINAL PAGE 19 1.3.2 CARGO ORBITAL TRANSFER VEHICLE (COTV OF POOR QUALITY

This element includes the COTV vehicle and operations required to support the satellite system assembly and operation. Included is the LEO-to-GEO transfer of space construction and support equipment, satellite system hardware, spares, and propellants required throughout the satellite lifetime.

The Rockwell cargo orbital transfer vehicle is a high specific impulse configuration that is possible with electric propulsion. The concept is shown in Figure 1.3-3 and has a payload capability of 5.17×10^6 kg (equivalent to 23 HLLV payloads) with a 6 month round trip time per flight.

COTV fleet procurement and operations are detailed in sections 1.3.2.1 and 1.3.2.2, respectively.

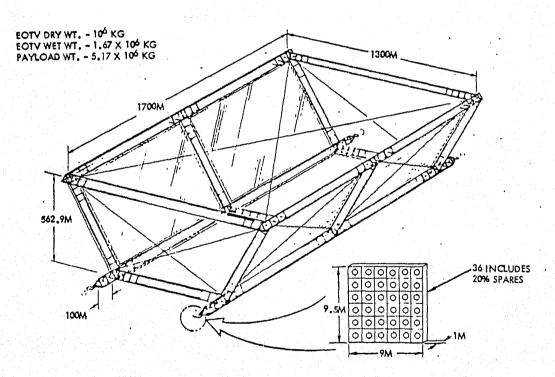


Figure 1.3-3. EOTV Reference Configuration

1.3.2.1 COTV FLEET

This element includes the vehicle fleet procurement required for the SPS.

The electric OTV structural configuration is essentially the same as that employed for the satellite bay. It has a weight of 871,753 kg's. The EOTV weight and payload summary is shown in Table 1.3-5.

Table 1.3-5. EOTV Weight Summary (kg) (GaAlAs)

SOLAR ARRAY		200 756	588,196
CELL/STRUCTURE		299,756	4 7 7 7
POWER CONDITIONING		288,440	
THRUSTER ARRAY (4)			96,685
THRUSTERS/STRUCTURE		10,979	
CONDUCTORS		4.607	
BEAMS/GIMBALS		2,256	
PROPELLANT TANKS		78,843	
ATTITUDE CONTROL SYST	EM	,	186,872
POWER SUPPLY (INCL.	ENERGY STORAGE)	184,882	
SYSTEM COMPONENTS		274	
PROPELLANT TANKS		1.716	
EOTV INERT WEIGHT			871,753
25% GROWTH			217,938
TOTAL INERT WEIGHT			1,089,691
PROPELLANT WEIGHT			666,660
TRANSFER PROPELLANT		655,219	
ACS PROPELLANT		11,441	
EOTV LOADED WEIGHT			1,756,351
PAYLOAD WEIGHT			5,171,318
LEO DEPARTURE WEIGHT			6,927,669

The thruster array consists of 36 units at four locations for a total of 144 thrusters with a maximum of 64 thrusters operable simultaneously. The total attitude control system and thruster array mass is equal to 283,557 kg's per EOTV.

The EOTV CERs are the same as those used for the satellite costs on the same subsystem elements. The replacement capital investment calculation is based on an attrition factor of 5-6% of each flight vehicle. Table 1.3-6 lists the elements of cost for the EOTV.

Table 1.3-6. EOTV Cost Elements

WBS NO.	DESCRIPTION
1.3.2.1.1	PRIMARY STRUCTURE
1.3.2.1.2	SECONDARY STRUCTURE
1.3.2.1.3	CONCENTRATOR
1.3.2.1.4	SOLAR BLANKET
1.3.2.1.5	SWITCHGEAR AND CONVERTERS
1.3.2.1.6	CONDUCTORS AND INSULATION
1.3.2.1.7	ACS HARDWARE
1.3.2.1.8	INFO MANAGEMENT AND CONTROL

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.2.1.1 PRIMARY STRUCTURE

	INPUT P	ARAMETERS			INPUT	COEFFICIENTS	
	30890.0000	TF=	1.000000		CDCER=	0.023000	
M=	2059.00000	=M3.0	0.0		CDEXP=	0.800000	
C F=	1.000000	21=	6.000000		CICER=	0.000050	
PH I=	1.000000	Z2=	60.000000	را المراكز المنظم ا ولا المنظم ا	CIEXP=	1.00000	
_R=	0.003500	Z3=	44.000000			선생님 선생님 그 아이들 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그 그	
DF≅	0.020000	Z4=	22.000000	25=	20.0	00000	
CALCUL	ATED VALUES	KG	SUM TO	1.3.2.1	na managang ng gala - na - managang kanaganan a kan	\$, MILLIONS	
CD=CDCER X	T X DF)XX(CDEXP) X CF				3.930	
CLRM=CICER >	((M)XX(CIEXP) X	CF X TF				0.103	
#RM =T / M		entropiane programme de la company de la				15.002	
E =1.0 + L	.OG(PHI) / LOG(2	• 0)				1.000	
CTFU=(CLRM /	' E)X((#RM X Z1+	.5)XX(E) -0.	.5XX(E))			9.267	
CTB = ((CLRM)	/E)X((#RM X Z	3 + 0.5)XX(E	=) -0.5XX(E))) / Z3	1.544	
CIPS=CTB*Z4/	1 22 - 11 1, 12 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					0.566	
CPCI =0	CTB X R					0.005	
CORM = C	DEM OR CTB*Z5/Z2	/ENYR				0.017	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION 1.3.2.1.2 SECONDARY STRUCTURE

	INPUT	PARAMETERS			INPUT COEFFIC	CIENTS	
	14918.0000	TF=	1.000000	CDCER	o	156000	
M=	5.000000	=M30	0.0	CDEXP	= 0	511000	
C F=	1.000000	Z1=	6.000000	CICER	= 0	101000	
PHI=	0.980000	Z 2=	60.000000	CIEXP	= 0	355000	
R=	0.003500	Z3=	44.000000				
DF=	0.050000	Z 4=	22.000000	Z5 =	20.000000		
CALCUL	ATED VALUES	KG	SUM TO 1	.3.2.1	nyangang pagangan salah pagangan aut man-aga na minara m	\$,MIL	LIONS
CD=CDCER X	(T X DF)XX(CDEX	Y) X CF				4.58	2
CLRM=CICER	X (M)XX(CIEXP)	CF X TF				0.17	9
#RM =T / M					2'	983.600	
E =1.0 +	LOG(PHI) / LOG(2	2.0)				0.971	
CTFU=(CLRM	/ E)X((#RM X Z1-	5)XX(E) -().5XX(E))			2478.75	0
CTB = ((CLRM	1/E)X((#RM X	73 + 0.5)XX	E) -0.5XX(E)))	Z3	389.82	0

142.934

1.364

4.331

COMMENTS

CIPS=CTB*Z4/Z2

CRCI =CTB X R

CC&M = O&M OR CTB*Z5/Z2/ENYR

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.2.1.3 CONCENTRATOR

	INPUT	PARAMETERS			NPUT COEFFICIENTS	
T =	1800000.00	TF=	1.000000	CDCER=	0.027000	
M=	450000.000	=M30	0.0	CDEXP=	0.394000	and the same of th
CF=		Z 1 =	6.000000	CICER=		
PHI≡	0.980000	Z2=	60.000000	CI EXP=	0.950000	e de la companya della companya della companya de la companya della companya dell
R=	0.003500		44.000000			
DF=	0.020000	Z 4=	22.000000	Z5=	20.000000	
CALCUL	ATED VALUES	SQ M	SUM TO	1.3.2.1	\$,MI	LLIONS
CD=CDCFR X	(T X DF)XX(CDEX	P) X CF			1.6	85
CLRM=CICER	X (M)XX(CIEXP)	X CF X TF			0.7	04
#RM =T / M					4.000	need a single garrier street, and described with the street
E =1.0 +	LOG(PHI) / LOG(2.0)			0.971	
CTFU=(CLRM	/ E)X((#RM X Z1	+.5)XX(E) -0).5XX(E))		15.8	18
CTB = ((CLRM	1/E)X((#RM X	Z3 + 0.5)XX(E) -0.5XX(E))) / Z	3 2.4	94
CIPS=CTB*Z4	+/Z2				0.9	14
CRCI =	CTB X R				0.00	09
= M303	O&M OR CTB*Z5/Z	2/ENYR			0.0	28
COMMENTS						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.2.1.4 SOLAR BLANKET

MTLS \$33/SQ M & PROCESSING \$34/SQ M.

		NPUT PARAMETERS		INPUT COEFFICIENTS				
	T= 900000.000) TF=	1.000000	CDC ER =	0.161400			
	M= 18750.000		0.0	CDEXP=	0.394000	. :		
	CF= 1.000	0000 Z1=	6.000000	CICER=	0.000067			
	PHI= 0.99	0000 Z 2=	60.000000	CIEXP=	1.000000			
	R= 0.00	3500 Z3=	44.000000					
	DF= 0.020	0000 Z4=	22.000000	Z5 = 20.00				
	CALCULATED VALUES	SQ M	SUM TO 1.3	.2.1	\$,MILLIONS	til general og skalender og skal		
	CD=CDCER X (T X DF)XX	CDEXP) X CF			7.664			
	CLRM=CICER X (M)XX(CI	EXP) X CF X TF			1.256			
ㅂ	#RM =T / M				48.000	a da u ugu jumak danéh kamujuji juma - gangun		
210	E = 1.0 + LOG(PHI) /		0.986					
	CTFU=(CLRM / E)X((#RM	X Z1+.5)XX(E) -0.		338.117				
	CTB =((CLRM/E)X((#RM)	C Z3 + 0.5)XX(E	E) -0.5XX(E))) / Z3	54.757			
	CIPS=CTB*Z4/Z2				20.077			
	CRCI = CTB X R			and the second s	0.192	· A - and the second se		
	CC&M = O&M OR CTB	×Z5/Z2/ENYR			0.608			
	COMMENTS NASA/ADL NAS 9-152 \$67/SQ M	294 MARCH 1978						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.2.1.5 SWITCHGEAR AND CONVERTERS

INPUT PARAMETERS	INPUT COEFFICIENTS
M= 719.000000 06M= 0.0 CD CF= 1.500000 Z1= 6.000000 CI PHI= 0.950000 Z2= 60.000000 CI R= 0.001111 Z3= 44.000000	OCER = 0.158000 OEXP = 0.297000 ICER = 0.000400 EXP = 1.000000
DF= 0.500000 Z4= 22.000000 Z5= CALCULATED VALUES KG SUM TO 1.3.2.1	20.000000 \$,MILLIONS
CD=CDCER X (T X DF)XX(CDEXP) X CF	2.054
CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.431
₩ #RM =T / M E =1.0 + LOG(PHI) / LOG(2.0)	3.999 0.926
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	8.760
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))	/ Z3 1.268
CIPS=CTB*Z4/Z2	0.465
CRCI = CTB X R	0.001
COMMENTS	0.014

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.2.1.6 CONDUCTORS AND INSULATION

	INPUT PARAMETERS		INPUT	COEFFICIENTS	
T= 357675	5.000 TF=	1.000000	CDCER=	0.158000	
M= 7452	2.00000 O&M=	0.0	CDEXP=	0.297000	
	1.000000 Z1=	6.000000	CICER=		
the contract of the first of the contract of t	1.000000 Z2=	60.000000	CI EXP=	1.000000	ing the second s
	0.001111 Z3=	44.000000			
DF= (0.020000 Z4=	22.000000	Z5 = 20.0	00000	
CALCULATED VA	ALUES KG	SUM TO 1.3.	2.1	\$, MILLIONS	ur (miragasa ir mirad mirad mirad ir d anadasa danadasa
CD=CDCER X (T X D)	F)XX(CDEXP) X CF			2.205	
CLRM=CICER X (M)X)	X(CIEXP) X CF X TF			0.030	
#RM =T / M	and the same and t			47.997	and the second of the second o
E = 1.0 + LOG(PH)	() / LOG(2.0)			1.000	
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -	-0.5XX(E))		8.584	
CTB = ((CLRM/E)X((#	#RM X Z3 + 0.5)XX	((E) -0.5XX(E))) / Z3	1.431	and the second s
			ar e di cue di Guardia Sanggara Afrika	and the second of the second o	e de la companya de La companya de la co
CIPS=CTB*Z4/Z2				0.525	
CPCI =CTB X	R			0.002	
COEM = DEM OR	CTB*Z5/Z2/ENYR			0.016	
COMMENTS					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.2.1.7 ACS HARDWARE

		INPUT P	ARAMETERS	gang panggan ang manggan banggan ang mga bang Mga panggan ang mga banggan an	INPUT	COEFFICIENTS	
	T≡	283557.000	TF=	0.093800	CDCER=	1.122000	
	M=	1970.00000	= M3 O	0.0	CDEXP=	0.190000	
	C F=		Z1=	6.000000	CICER=	0.057000	
	=IHq	0.950000	Z2=	60.000000	CIEXP=	0.729000	
	R=	0.003500	Z3=	44.000000			
	DF=	0.300000	Z 4=	22.000000	Z5 = 20.00	0000	
	CALCUI	LATED VALUES	KG	SUM TO 1.3.	2.1	\$, MILLIONS	aper "remail an ar se o e <u>a l'army ary ary aper de l'en aptice d'art</u> ène às
	CD=CDCER X	(T X DF)XX(CDEXP) X CF			9.697	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF			1.348	
B	#RM =T / M		the state and engages are commonted to the transposer			143.938	garin A Parin ir direct di repataminja min dan dimensionalesia
213	E = 1.0 +	LOG(PHI) / LOG(2	.0)			0.926	
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5) XX(E) -0.	5XX(E))		762.015	
	CTB = ((CLRM	1/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	109.634	maken. 1970k mustama deni lasa magganatkulum berlahad
	CIPS=CTB*Z4	4/22	in a san a san a san an Air. Na a san a			40.199	
	CRCI =	=CTB X R			and the control of th	0.384	parties a substitute of the contract of the co
	CC&M =	O&M OR CT8*25/22	/ENYR			1.218	
	COMMENTS						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.2.1.8 INFO. MGMT. AND CONTROL

		INPUT			INPUT CO	EFFICIENT	S		
	T= M= CF= PHI= R= DF=	0.0 0.0 0.0 1.000000 0.0 1.000000	TF= O&M= Z1= Z2= Z3= Z4=	1.000000 0.0 6.000000 60.000000 60.000000	C D E	ER = XP = ER = XP = 0.0	0.0 0.0 0.0 0.0		
	CALCULA	TED VALUES	\$	SUM TO 1.	3.2.1	na _{surenda} salam siyah danangan panam mendan pan yang persemb	er democratic es mandanas es destacantes de mandanas es mandanas e	\$, MILLIONS	n va var vij namenimente. Mania monime kansat sije subšu u
	CD=CDCER X (T X DF)XX(CDEXP) X CF		en e	and the second of the second o		0.0	
	CLRM=CICER X	(M)XX(CIEXP)	CF X TF					0.0	
В	#RM =T / M		The second secon		again, again lagai (amma se alang 1 de 1 de 1944) desta batanta d	u. 6 ji. ji. biya kara mad ina. Ingindandi inadi, yanahim int	0.0	- Production of the Control of the C	and the second s
214	E =1.0 + L	.OG(PHI) / LOG(2	.0)			and the second s	0.0		
	CTFU=(CLRM /	' E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				0.0	
Security Sec.	CTB = ((CLRM)	'E)X((#RM X Z	/ Z3	reported sources (1997) and the control of the cont	0.0				
	CIPS=CTB*Z4/	' Z2						0.0	
	CRCI =0	CTB X R	and the second s		and specificacions and the second second second second second	g and the state of	entantale i silaten projek je kalinina e i mino. Silahkura inarka	0.0	, que de las physicias, incluides ama america debusamento.
	CORM = C	D&M OR CTB*Z5/Z2	?/FNYR					0.0	

1.3.2.2 COTV OPERATIONS

Necessary vehicle operations (user charge per flight including payload integration) is included in this element.

The flight life of the EOTV is estimated at 20 round trips from LEO to GEO. Four hundred forty-four flights are required for the construction of 60 satellites and an additional 396 flights will maintain the operational satellites for the 30 year period. Seven flights are required to build the first satellite.

The calculations used in this cost estimate are presented in Table 1.3.2.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.2.2 COTV OPERATIONS

	INPUT P	ARAMETERS			INPUT	COEFFICIENTS	
T= M= C F=		TF= 0&M= Z1=	1.000000 0.0 7.000000		CDCER = CDEXP = CICER =	0.0 0.0 0.630000	
PHI= R= DF=	1.000000 0.0 1.000000	Z 2= Z 3= Z 4=	60.000000 840.000000 444.000000	Z5=	CIEXP= 396.0	1.000000	
CALCULAT	TED VALUES	FLIGHT	SUM TO	1.3.2		\$, MILLIONS	
CD=CDCER X ()	T X DF)XX(CDEXP	X CF				0.0	
CLRM=CICER X	(M)XX(CIEXP) X	CF X TF				0.630	
#RM = T / M		of the constitution of the				1.000	
E = 1.0 + L0	OG(PHI) / LOG(2:	.0)			ر از این از از معاصد از این از این از این این این از	1.000	
CTFU=(CLRM /	E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			4.410	
CTB = ((CLRM/E	E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	0.630	
CIPS=CTB*Z4/Z	22					4.662	
CRCI = C1	rb X R			-		0.0	
C C E M = 08	M OR CTB*Z5/Z2	/ENYR				0.139	
COMMENTS							

1.3.3 PERSONNEL LAUNCH VEHICLE (PLV)

This element includes the space shuttle growth vehicles and operations required to support the satellite system assembly and operation. Included is the launch to LEO and return of all personnel and priority cargo required throughout the satellite construction period and operational lifetime.

In addition to the earth-to-LEO transfer of personnel during satellite construction and operational periods, the space shuttle growth vehicle will 1) accommodate the transfer of personnel and 2) with the cargo/engine module adaptation, will transfer the cargo/material needed for precursor activities dealing with the LEO Base, Space Construction Base, and the initial EOTV-335 mW precursor test article. Shuttle goowth vehicle and flight requirements for the SPS Grogram are identified in Table 1.3.3.

Table 1.3.3. Shuttle Growth Vehicle and Flight Requirements

ORIGINAL PAGE IS OF POOR QUALITY

VEHICLE/ITEM DESCRIPTION	PRECURSON	TEU TEU	SATELLITE	SATELLITE	VEHICLE	TOTAL MEL	PLV VE.	CARCO VEHICO
44.	·		ILCLE RE	QUIREME		A 100 Maria (1000)		
HUTTLE ORBITER STANDARD VERSION)	(1)	(3)	15	37	26	78	1 EA	
HUTTLE CARGO CARRIER & MODULE	2				1	3		1 EA
XTERNAL TANK	(201)	(60)	1541	3694		5235	1 EA	1 EA
IQUID ROCKET SOOSTER	(6)	(10)	34	74	216	324	2 EA	2 EA
		FL	IGHT RE	QUIREME	NTS			
PERSONNEL LAUNCH /EHICLE (PLV)	(72)	(60)	1412	3694		5106		
CARGO CARRIER AUNCH VEH. MODULE	129					129		

The Personnel Launch Vehicle (PLV) is described in section 1.3.3.1 along with the Shuttle derived cargo carrier and engine module required to support the precursor program. PLV operations are described in section 1.3.3.2. The Personnel Module is covered in section 1.3.5.1.

1.3.3.1 PLV FLEET

This element includes the vehicle fleet procurement required to support the SPS program. Included are the vehicles for personnel transfer from earth to LEO and for cargo as needed to support the precursor phase of SPS program development.

The PLV consists of a standard Shuttle Orbiter, an external tank, and two liquid rocket boosters. The cargo vehicle configuration is achieved by replacing the orbiter with a cargo carrier and engine module. The external tank and liquid rocket booster (Figure 1.3.3) are common systems used on the Shuttle derived personnel and cargo vehicles. The integral, SSME-35 powered concept requires four engines with a thrust-to-weight ratio at lift-off of 1.335, which is adequate for both nominal and abort trajectories.

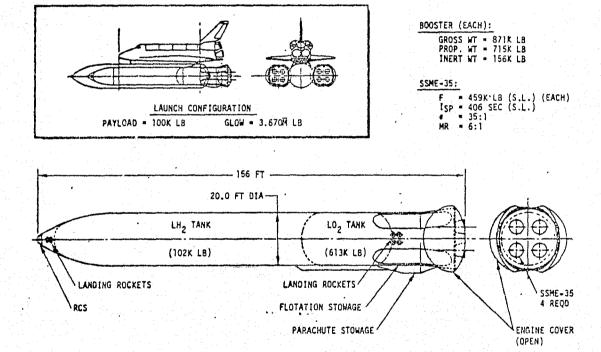


Figure 1.3.3. PLV Configuration

Cost estimates were developed from work produced under the Rockwell Shuttle Growth Study Contract NAS8-32015 of May, 1977. DDT&E, Shuttle Orbiter, external tank, liquid rocket booster, the engine module costs, and projections on operational requirements were identified by comparative evaluation with the Shuttle growth data base. Many different concepts for reducing Shuttle operations costs were examined in the study, but overall cost characteristics clearly reflected the choice of propulsion which lead to the SSME-35 powered LRB as a considered alternative.

Elements of the STS PLV and cargo fleet were individually analyzed on the basis of systems per vehicle, vehicle life, asset rep lacement and operational aspects. A PLV orbiter 30 year replacement factor of 0.5 equivalent vehicles

was used for each orbiter in the fleet. The external tank is an expended item after each flight and the LRBs are to be replaced on the basis of two boosters for each one in the fleet. An attrition/spares factof of 0.5 equivalent vehicles is also used for the cargo/engine module.

DDT&E and system cost estimates are identified in the following tables:

The state of the state of

Table No.	<u> Item</u>
1.3.3.1.1	STS-PLV Orbiter
1.3.3.1.2	STS-PLV External Tank
1.3.3.1.3	STS-PLV Liquid Rocket Booster
1.3.3.1.4	STS-Cargo Carrier and Engine Module

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.3.1.1 STS-PLV ORBITER

	INPUT	PARAMETERS			IN	PUT COEFFICIE	ENTS	
T= M= CE=	1.000000 1.000000 1.000000	08M= Z1=	1.000000 0.0 3.000000		CDCER= CDEXP= CICER=	0.0 600.00		
PHI= R= DF=	0.920000 0.014444 1.000000	Z2= Z3= Z4=	60.000000 78.000000 15.000000	Z 5=	CIEXP=	37.000000		
CAL CUL A	TED VALUES	SET	SUM TO	1.3.3.1			\$, MILLIONS	
CD=CDCER X (T X DF)XX(CDE)	(P) X CF					0.0	
CLRM=CICER X	(M)XX(CIEXP)	X CF X TF					600.000	
#RM = T / M	agricultura (m. p.	e par tem again ference es esta per es	a mayan dagaa sagaa karang darang magaan sagaan				.000	
E =1.0 + L0	OG(PHI) / LOG(2.0)					0.880	
CTFU=(CLRM /	E) X ((#RM X Z)	+.5)XX(F) -0.	5XX(E))				1682.531	
CTB = ((CLRM/	E) X((#RM X	Z3 + 0.5)XX(E) -0.5XX(E))	n - Inn a Sangapanna (Inna Inna Inna Inna Inna Inna Inna) / Z3		401.360	
CIPS=CTB*Z4/Z	72						100.340	
CRCI =C	TB X R				and the second s	- myleter	5.797	
COEM = 08	M OR CTB*Z5/Z	2/ENYR					8.250	
COMMENTS								

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.3.1.2 STS-PLV EXTERNAL TANK

	INPUT PARAMETERS	NPUT CREFFICIENTS
	T= 1.000000 TF= 1.000000 CDCER= M= 1.000000 D&M= 0.0 CDEXP= CF= 1.000000 Z1= 261.000000 CICER= PHI= 0.920000 Z2= 60.000000 CIEXP= R= 0.0 Z3= 5235.00000	0.0 , 4.000000 1.000000
	DF= 1.000000 Z4= 1541.00000 Z5= 36	
	CALCULATED VALUES SET SUM TO 1.3.3.1	\$, MILLIONS
	CD=CDCER X (T X DF)XX(CDEXP) X CF	0.0
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	4.000
 j	#RM =T / M	1.000
	E =1.0 + LOG(PHI) / LOG(2.0)	0.880
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	606.205
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	1.623
	CIPS=CTB*Z4/Z2	41.579
	CRCI = CTB X R	0.0
	CCEM = OEM OR CTB*Z5/Z2/ENYR	3.330
	COMMENTS.	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.3.1.3 STS-PLV LIQ. ROCKET BOOSTER

	INPUT P	ARAMETERS			INPUT COEF	FICIENTS	
	1.000000	TF=	1.000000	CDC	P = 13	04-0000	
M=	1.000000	=M30	0.0	CDEX	to a division have continued and the continued and the same of the	1.000000	describbings - and the same of the description of the same of the
C F=	1.000000	Z 1=	5.000000	CICE	R = 1	95.300003	
PHI=	0.920000	Z2=	60.000000	CIEX	(P =	1.000000	and the second of the second o
R=	0.060000	73=	162.000000				
D F=	1.000000	Z 4=	17-000000	Z5=	37.00000		
CALCULAT	ED VALUES	SET	SUM TO 1.	3.3.1		\$, MILL IO	NS
CD=CDCER X (T	X DF)XX(CDEXP) X CF				1304.000	
CLRM=CICER X	(M)XX(CIEXP) X	CF X TF				195.300	
#RM =T / M		p the second second second play about 1 or 10 mayer the second			مستعدر سيست و مستدر الميد و المجار عام الرفوان المستعدد	1.000	ng, ngay, man <u>mangaman ng pagan</u> ni kananang nambih minampun ni ng tang alambi
E = 1.0 + LO	G(PHI) / LOG(2	.01		راً به المحالية المح المحالية المحالية ا		0.880	
CTFU=(CLRM /	E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			873.985	
CTB = ((CLRM/E) X ((# R M X Z	3 + 0.5)XX(E) -0.5XX(E))) /	Z3	119.967	
CIPS=CTB*Z4/Z	2					33.991	
CRCI =CT	B X R					7.198	d by the company of the particular particular and the particular particular and the particular particular part
30 = M3O3	M OR CTB*Z5/Z2	/ENYR				2.466	
COMMENTS							

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.3.1.4 STS CARGO CARRIER AND EM

	INPL		INPUT COEFFICIENTS				
	T= 1.00000 M= 1.00000 CF= 1.00000 PHI= 0.92000 R= 0.0 DF= 1.00000	00	1.000000 0.0 3.000000 60.000000 3.000000	CDCER CDEXP CICER CIEXP	= ;	245.000000 1.000000 265.800049 1.000000	
-	CALCULATED VALUES CD=CDCER X (T X DF)XX(CO	SEXP) X CF	SUM TO 1.3	3.3.1		\$,MILLIONS 245.000	
	CLRM=CICER X (M)XX(CIEX	Y) X CF X TF				265.800	
B-223	#RM =T / M F =1.0 + LOG(PHI) / LO	06(2.0)				1.000	
	CTFU=(CLRM / E)X((#RM X	Z1+.5)XX(E) -0.	5XX(E))			745.362	
	CTB =((CLRM/E)X((#RM X	23 + 0.5)XX(E	-0.5XX(E))) /	Z3	248.454	
• • • • • • • • • • • • • • • • • • • •	CIPS=CTB*Z4/Z2				- مديدي رائيدي. رئيد	12.423	***
un Antonomia is A com	CRCI = CTB X R			and the state of t		0.0	
	COEM = OEM OR CTB*Z5 COMMENTS	5/Z2/ENYR				0.0	

1.3.3.2 PLV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS program.

A total of 5,235 flights are required of the Shuttle derived personnel and cargo vehicle -- 1,412 for construction, 3,694 for operations, and 129 for the precursor program. The 1,412 PLV flights for construction include 72 for the precursor effort and 60 for the TFU satellite.

Cost estimates per flight were projected after an engineering analysis of the operational costs and vehicle elements identified in the Rockwell Shuttle Growth Study (NASS-32015). Tables 1.3.3.2.1 and 1.3.3.2.2 cover operational cost estimates.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.3.2.1 PLV OPERATIONS

COMMENTS

INPUT PARAMETERS				INPUT COEFFICIENTS				
T= M= CF= PHI=	1.000000 1.000000 1.000000 1.000000	TF= 0&M= Z1= Z2=	1.000000 0.0 132.000000 60.000000		CDCER= CDEXP= CICER= CIEXP=		or METAL I CONTRACTOR OF THE PARTY OF THE PA	
R= DF=	0.0 1.000000	Z3= Z4=	5106.00000 1412.00000	Z5 =	3694.	00000		
CALCULATE	D VALUES	FLIGHT	SUM TO	1.3.3.2	Partition is along when depoplers by the manufacture security and		\$,MILLIONS	
CD=CDCER X (T	X DF)XX(CDEX	P) X CF					0.0	
CLRM=CICER X (M)XX(CIEXP)	X CF X TF					9.200	
#RM = T / M							1.000	and the second section of the section of t
E =1.0 + LOG	(PHI) / LOG(2.0)				The state of the s	1.000	
CTFU=(CLRM / E)X((#RM X Z1	+.5)XX(E) -	0.5XX(E))				1214.400	
CTB =((CLRM/E)	X((#RM X	Z3 + 0.5)XX	(E) -0.5XX(E))		1 / Z3		9.200	
CIPS=CTB*Z4/Z2				e en			216.507	
CRCI = CTB	X R	e santa para new Maranta para new angang pang pang pang pang					0.0	
M30 = M300	OR CTB*Z5/Z	2/ENYR					18.880	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.3.2.2 STS HLLV CARGO OPERATIONS

	INPUT PARAMFTERS			INPUT COEFFICIENTS			
T= M= C F= PH I= R= DF=	1.000000 1.000000 1.000000 1.000000 0.0 1.000000	TF= O&M= Z1= Z2= Z3= Z4=	1.000000 0.0 129.000000 60.000000 129.000000	CDCER= CDEXP= CICER= CIEXP= Z5= O.	0.0 0.0 8.750000 1.000000		
CD=CDCER X (T	ED VALUES X DF)XX(CDEXF (M)XX(CIEXP) >		SUM TO 1.	3.3.2	\$, MILLIONS 0.0 8.750	us to America Wales Turban (ed. 1971) for	
	G(PHI) / LOG(2 E)X((#RM X Z14	and the second s).5XX(E))		1.000 1.000 1128.750		
CTB = ((CLRM/E CIPS=CTB*Z4/Z CRCI = CT		3 + 0.5)XX	(E) -0.5XX(E))) / Z3	8.750 18.813 0.0	en e	
	M OR CTB*Z5/Z2	/ ENYR			0.0	He applied in gain to gay to easy to chief	

The state of the s

1.3.4 PERSONNEL ORBITAL TRANSFER VEHICLE (POTV)

This element includes the POTV vehicles and operations required to support the satellite system assembly and operation. Included is the LEO-to-GEO and return of all personnel and priority cargo required throughout the satellite construction and operational periods.

All of the POTV options evaluated utilize a single stage propulsive element that is fueled in LEO and refueled in GEO for the return flight. The reference configuration is illustrated in Figure 1.3.4 where the POTV (a propulsive stage) is capable of transporting a 60-man personnel module (PM) of 18,000 kg. The vehicle is costed in section 1.3.4.1 and POTV operations are covered in section 1.3.4.2.

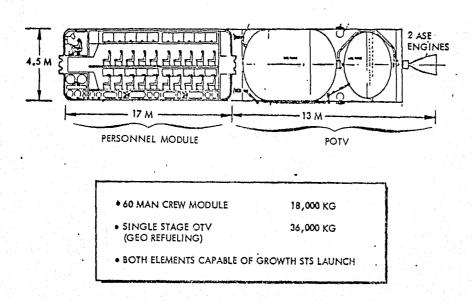


Figure 1.3.4. POTV Configuration

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1.3.4.1 POTV FLEET

The vehicle fleet procurement required to support the SPS program is included in this element. The POTV is a single stage OTV of 36,000 kg with refueling at GEO for the return to LEO. Propellants are carried from LEO to GEO by the EOTV. The SPS HLLV carries the construction, crew expendables, and POTV propellants to LEO. The Shuttle Orbiter carries the crew in a personnel module (PM) to LEO for transfer to the POTV.

The single stage OTV configuration selected is a scaled version of those concepts presented in the BAC FSTSA NAS9-24323 contract and engineering analyses presented in Exhibits A/B of the Rockwell contract NAS8-32475. DDT&E estimates considered fewer engines, a significant difference in mass, and the degree of development required for the engines. Engineering analyses of available vehicle estimates projected a POTV cost based on the design and complexity of the vehicle.

POTV cost estimates are presented in Table 1.3.4.1 for a total fleet of 196 vehicles with: 1) 12 for personnel involved in satellite construction, 2) 37 for SPS operational activities, and 3) an attrition factor of 3 equivalent vehicles to keep the fleet fully operational.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.4.1 POTV-FLEET

			ADAMETERS				e de la composição de la La composição de la compo
		INPUL P	ARAMETERS		TNPI Programme	JT COEFFICIENTS	
	T≡	1.000000	TF=	1.000000	CDCER=	350.000000	
	M=	1.000000	eM30	0.0	CDEXP=	1.000000	
	CF= PHI=	1.000000	Z 1=	4.000000	CICER=	15.000000	
	P. 1 = R =	0.920000	Z2= Z3=	60.000000 196.000000	CIEXP=	1.000000	
	DF=	1.000000	Z4=		Z5 = 3	7.000000	
		2000000		12100000			
	CALCULATE	D VALUES	SET	SUM TO 1.	.3.4	\$,MILLION	S
	CD CDCCD V /T	V DELVATEDEVA	, in the second				
	CD=CDCER X (T	X DEIXX (CDEXP) X CF			350.000	
	CLRM=CICER X (M)XX(CIEXP) X	CF X TF			15.000	
m	#RM = T / M	gericht felder erminnen ungen gene die ermit kompten Lause gegel selde mat Ausgeber, ingegegegeld den Ausber-				1.000	
-229	E = 1.0 + LOG	10011 / 10012	0.1			0.000	
φ	E -1.0 T LUG	trati / Luciz		The second secon	The second section of the section of the section of the second section of the section of t	0.880	
	CTFU=(CLRM / E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))		54.764	
		<u> </u>					
	CTD - (/CLD# /E)	VIEUDH V 7		C A CVV/CN N		0.010	
	CTB = ((CLRM/E)	X (I # RM X Z.	3 + 0.51XXI	E1 -0.5XX(E1)) / Z3	9.010	
# : 1	CIPS=CTB*Z4/Z2				The second secon	1.802	
	CRCI =CTB	X R				0.736 0.185	and the second
		00 070 77 (70				PER	
	CULM = ULM	OR CTB*Z5/Z2	ZENYK			0.185	
	COMMENTS						رزا المشاوي المحار المسود المداد داد
						28	
						OUAL TO	
	The second section of the second section is a second section of the second section sec		The state of the s	The company of the control of the co	e ntata de la composición de la compositión de l	25	
	그 문제 함께 함께 그렇게 함	얼마 살아보다 나를 살아 있다.					

1.3.4.2 POTV OPERATIONS

This element includes the necessary vehicle operations (user charge per flight including payload integration) required to support the SPS program with required personnel.

The primary operational cost of the POTV is the cost of fuel. A total of 4,880 flights were costed on this basis where 1,220 flights were for satellite construction; 3,660 for operations and maintenance; and 45 of the 1,220 needed to support TFU activities. Table 1.3.4.2 presents the results of this analysis.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.4.2 POTV-GPERATIONS

		INPUT P	ARAMETERS	INPUT			COEFFICIENTS	
	T= M= CF=	1.000000 1.000000 1.000000	TF= 0&M= Z1=	1.000000 0.0 45.000000	C	DCER= DEXP= ICER=	0.0 0.0 0.033742	
	PH I = R = D F =	1.000000 0.0 1.000000	Z 2= Z 3 = Z 4=	60.000000 4880.00000	<u>C</u>	3660.0	1.000000	
	CALCULATED		\$	SUM TO 1.			\$, MILLIONS	
	CD=CDCER X (T X CLRM=CICER X (M						0.0	
B-23	#RM =T / M E =1.0 + LOG(1.000	
31	CTFU={CLRM / E}	The second secon		.5XX(E))			1.000	
	CTB = ((CLRM/E)X	((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3	0.034	
	CIPS=CTB*Z4/Z2	in and the second s Second second se					0.686	San Carlos C Carlos Carlos Car
- -	CRCI = CTB	X R OR CTB*Z5/Z2	/ ENYR				0.0	<u> </u>
	COMMENTS	ON 015-23722						en e

1.3.5 PERSONNEL MODULE (PM)

This element includes the PM units and operations required to support the satellite system assembly and operation. Included in the earth-to-LEO-to-GEO and return transfer of all personnel and critical hardware items required throughout the satellite construction and operational periods. The PM provides a crew habitat during the orbit-to-orbit transfers of personnel as well as during the trip from earth. An illustration of the PM was shown in Figure 1.3.4. It has a 60-man capacity and is approximately 17 m long by 4.5 m in diameter. The Shuttle is used for the earth-to-LEO transfer and the POTV handles the round trip movement from LEO-GEO-LEO.

1.3.5.1 PM FLEET

Procurement of the PM as required to support the SPS program is covered in this element. The PM is operated by a pilot and co-pilot and contains the major systems of life support, communication, seating, and support facilities. A total of 4 PMs are needed to support the program and 2 equivalent PMs are considered sufficient to provide spares and major overhaul components during the program. Four vehicles will be required to build the satellite TFU and early program supporting elements such as the LEO Base and SCB.

Engineering cost projections were based on Rockwell company-funded studies of 1976 where DDT&E, a pair of 68 passenger modules, and the orbiter modification kits were costed from internal design specifications. PM fleet procurement costs are presented in Table 1.3.5.1.

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TABLE	ROCKWELL 1.3.5.1 PM	SPS CR-2 REFERE	NCE CONFIGURATI	ON

an interpretation of the property of the contraction of the contractio

							ALL CAPECTA TELEFO		
		ARAMETERS		INPUT COEFFICIENTS					
	Τ=	1.000000	TF=	1.000000		CDCER=	118.000000		
	M=	1.000000	=M30	0.0		CDEXP=	1.000000		
	C F=	1.000000	Z1=	4.000000		CICER=	54.399994		
	PH I=	0.920000	72=	60.000000	i je m ga anjan i	CIEXP=	1.000000		
	R= DF=	0.004444	Z3= Z4=	12.000000	75=		3.000000		
		1.000000		2.00000			3.5555555		
	CALCULATED	VALUES	SET	SUM TO 1.	3.5	and a part of the part of the second of the	\$,	MILLIONS	
	CD=CDCER X (T X	DF) X X (CDEXP	X CF			and the second	118	•000	
	CLRM=CICER X (M)XX(CIEXP) X	CF X TF				54	• 400	
ᅜ	#RM =T / M						1.000		, irrae.co
-234	E =1.0 + LOG(PHI) / LOG(2	.0)		and the second		0.880		
	CTFU=(CLRM / E)	X((#RM X Z1+	.5) XX(E) -0).5XX(E))			198	.610	
	CTB = ((CLRM/E)X	(3 + 0.5)XX(E) -0.5XX(E))) / Z3	44	.737	
	CIPS=CTB*Z4/Z2						0	•746	·
· · · · · · · · · · · · · · · · · · ·	CRCI = CTB	X R					0	.199	
	0 M30 = M300	OR CTB*Z5/Z2	/ENYR				0	.075	
	COMMENTS								

The state of the state of

1.3.5.2 PM OPERATIONS

This element includes the necessary operations (user charge per flight including payload integration) required to support the SPS program.

A PM crew (pilot and co-pilot) will command the module during earth-to-LEO trips on the Shuttle and complete the procedures of leaving the Shuttle and making the POTV hook-up for transfer to GEO. The crew will monitor passenger off-loading/transfer to and from the LEO Base, SCB, or satellite O&M Base. Two man-days are calculated per trip which includes a rest period at GEO and a day off after the trip. An average of 4,993 round trip flights are projected from earth to GEO and back. A total of 132 flights are needed for the precursor and TFU programs. The engineering estimates of PM operations are presented in Figure 1.3.5.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.5.2 PM OPERATIONS

INPUT PARAMETERS INPUT	COEFFICIENTS
T= 1.000000 TF= 1.000000 CDCER=	0.0
M= 1.000000 0EM= 0.0 CDEXP= CF= 1.000000 Z1= 132.000000 CICER= PHI= 1.000000 Z2= 60.000000 CIEXP=	0.0 0.025000 1.000000
R= 0.0 Z3= 4993.00000 DF= 1.000000 Z4= 1316.00000 Z5= 3677.	
CALCULATED VALUES FLIGHT SUM TO 1.3.5	\$, MILLIONS
CD=CDCER X (T X DF)XX(CDEXP) X CF	0.0
CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.025
#RM =T / M	1.000
E = 1.0 + LOG(PHI) / LOG(2.0)	1.000
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	3.300
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	0.025
CIPS=CTB*Z4/Z2	0.548
CRCI =CTB X R	0.0
COEM = OEM OR CTB*Z5/Z2/ENYR	0.051
COMMENTS	en de gradiante, en la companya de br>La companya de la co



1.3.6 INTRA-ORBITAL TRANSFER VEHICLE (IOTV)

This element includes the IOTV vehicles and operations required to support the satellite system assembly and operation. Included is the intra-orbit transfer of cargo between the HLLV, EOTV, construction facility, logistics support facility, and operational satellites.

1.3.6.1 IOTV FLEET

This element includes the necessary vehicle fleet procurement required to support the SPS program. The IOTV has been synthesized in terms of application and concept only. IOTV elements considered here are powered by a chemical (LOX/LH2) propulsion system. At least three distinct applications have been identified; (1) the need to transfer cargo from the HLLV to the EOTV in LEO and from the EOTV to the SPS construction base in GEO; (2) the need to move materials about the SPS construction base; and (3) the probable need to move men or materials between operational SPSs. Clearly the POTV, used for transfer of personnel from LEO to GEO and return, is too large to satisfy all intra-orbit requirements. A "free-flyer" teleoperator concept would appear to be a logical solution to the problem. A propulsive element was synthesized to satisfy the cargo transfer application from HLLV-EOTV-SPS base in order to quantify potential on-orbit propellant requirements. Pertinent IOTV parameters are summarized in Table 1.3.6.

SUBSYSTEM WEIGHT (kg) ENGINE (1 ASE) 245 PROPELLANT TANKS 15 STRUCTURE AND LINES 15 DOCKING RING 100 ATTITUDE CONTROL 50 OTHER 100 SUBTOTAL 525 GROWTH (10%) 53 578 TOTAL INERT PROPELLANT 300 TOTAL LOADED

Table 1.3.6. IOTV Design Parameters

A total of 840 IOTVs are needed to maintain intra-orbit cargo/operations flow during the program. One hundred ten vehicles will accomplish the construction phase and 100 vehicles are needed for satellite O&M. An attrition/spares fleet of equivalent vehicles was projected on the ratio of 3 units for each of the operational vehicles.

Cost estimates for the IOTV are engineering assessments based on POTV designs and similarities such as those of the common advanced space engine (ASE). Table 1.3.6.1 displays the applicable cost data.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.3.6.1 IDTV FLEET

INPUT PARAMETERS				COEFFICIENTS			
		1.000000	TF=	1.000000	CDCER=	100.000000	
	M=	1.000000	=M30	0.0	CDEXP=	1.000000	
	CF=	1.000000	Z 1 =	4.000000	CICER=	1.500000	
 	PHI=	0.920000	Z 2 =	60.000000	CIEXP=	1.00000	
	R=	0.350000	Z3=	840.000000	75 100		
	DF=	1.000000	24=	110.000000	Z5 = 100.	.00000	
	CALCULAT	TED VALUES	SET	SUM TO 1.	3.6	\$, MILL IO	NS
	CD=CDCER X (7	X DF)XX(CDEXP) X CF			100.000	
	CLRM=CICER X	(M)XX(CIEXP) X	CF X TF			1.500	
П	#RM =T / M					1.000	
239	F = 1.0 + LC	G(PHI) / LOG(2	• 0)		ر از	0.880	
	CTFU=(CLRM /	E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))		5.476	
	CTB = ((CLRM/E	E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))	1 / 23	0.758	• And (1) (1) (1) (1) (1) (1) (1) (1) (1) (1)
	CIPS=CTB*Z4/Z	2				1.389	
-	CRCI =CT	вхк				0.265	
	CCEM = DE	M OR CTB*Z5/Z2	/ ENYP			0.042	
	COMMENTS						

1.3.6.2 IOTV OPERATIONS

This element includes the necessary vehicle operations and propellant costs required to support the SPS program. It includes the on-orbit operational cost of transferring cargo at LEO and GEO.

A total of 41,940 IOTV flights are planned for LEO and GEO construction and operations/maintenance requirements of the program. The 22,811 flights needed for construction and the 19,979 for operations and maintenance are considered as equal missions for the purpose of costing. The propellant requirements were averaged and calculated at 1977 dollars of 0.07/kg for LO₂ and 3.27/kg for LH₂. A 40% mark-up was added per flight for other operational and maintenance charges. See Table 1.3.6.2.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.3.6.2 IOTV OPERATIONS

		INPUT P	ARAMETERS		INPU	T COEFFICIENTS	
	T=	1.000000 1.000000 1.000000 1.000000 0.0	TF= 06M= 21= 22= 23= 24=	1.000000 0.0 408.000000 60.000000 41940.0000 21961.0000	CDCER = CDEXP = CICER = CIEXP = 25 = 19979	0.0 0.0 0.000222 1.000000	
	CALCULATED	VALUES	FLIGHT	SUM TO 1		\$, MILLIONS	
5 	CD=CDCER X (T X	DF)XX(CDEXP) x cf		رده کا میرونی مصنوع در دهور مید درده کا میرونی مصنوع در دهور مید	0.0	
	CLRM=CICER X (M)	XX(CIEXP) X	CF X TF			0.000	
B	#RM =T / M					1.000	
241	E = 1.0 + LOG(F	PHI) / LOG(2	.0)		ر میں اور	1.000	
	CTFU=(CLRM / E)>	(((#RM X Z1+	.5) XX(E) -().5XX(E))		0.091	
	CTB = ((CLRM/E)X)	((#RM X Z	3 + 0.5)XX	E) -0.5XX(E))	1 / Z3	0.000	
	CIPS=CTB*Z4/Z2		and the second of the second o			0.081	
	CRCI = CTB	X R				0.0	nymant ppo tamanganya, a panta hiimata ta sinanga
	CORM = 08M C	OR CTB*Z5/Z2	/ENYR			0.002	
	COMMENTS						

1.3.7 GROUND SUPPORT FACILITIES

or the same of the

This element includes all land, buildings, roads, shops, etc., required to support the cargo handling, launching, recovering, refurbishment, and operations of the space transportation system.

1.3.7.1 LAUNCH FACILITIES

This element includes the design and construction of the actual launch facility and its associated equipment. Included are land, buildings, and equipment required to support the various crews. It also includes the required control centers and administrative facilities.

1.3.7.2 RECOVERY FACILITIES

This element covers the design, construction, and equipping of the actual recovery facilities.

1.3.7.3 FUEL FACILITIES

This element includes fuel production facilities, storage and handling facilities, transportation, and delivery and safety facilities for both the fuel and the oxidizer. Also included are the facilities for fuels used in the various orbital transfer facilities)

1.3.7.4 LOGISTICS SUPPORT

This element includes the land, buildings, and handling equipment for the receiving, inspection, and storage and packaging of all payloads to be launched except for fuels and oxidizers.

1.3.7.5 OPERATIONS

This element includes the planning, development, and conduct of operations at the ground support facilities. It includes both the direct and support personnel and the expendable maintenance supplies required for the ground support facilities operation and maintenance.

A cost estimate for ground support facilities is projected in Table 1.3.7 based on the Boeing final report, NAS9-14710, dated September 1977, Volume 4, Cost Estimates. It is judged that there is little difference in the cost of facilities in this report as compared with those projected for the transportation and operations requirements of this study.

ROCKWELL SPS CK-2 REFERENCE CONFIGURATION TABLE 1.3.7 GRUUND SUPPORT FACILITIES

	INPUT P	ARAMETERS		INF	OT COEFFICIENTS	
1=	1.000000	LH=	1.000000	CDCER=	1720.0000	
M=	1.000000	C&M=	1.775000	CDEXP=	0.0	4+
C F=	1.000000	21=	1.000000	CICER=	3195.00000	
PH1=	1.000000	Z 2=	60.000000	CIEXY=	0.0 () () () () () () () () () (
K≒	0.0011111	Z 3=	1.006000			
DF≅	1.620000	Z4=	1.000000	Z5=	0.0	
CALCULAT	TED VALUES		SUM FO 1.	3	\$,MILLIONS	
CD=CDCER X (7	T X DF)XX(CDEXP	X CF			1720.000	•
CLRM=CICER X	(M)XX(CIEXP) X	CF X TF			3195.000	
HRM =T / M		e e como escape de meso. E como escape de la br>El como escape de la	e de la composição de la Composição de la composição de la composiç		1.000	
E =1.6 + L0	J6(PHI) / LOG(2	(.)			1.000	
CIFU= (CLRM /	E)X((#KM X Z1+	5)xx(E) -	0.5XX(E))		3195.000	
Clb = ((CLRM/L	:)X((#RM X Z	+ 0.5)XX	(E) -0.5XX(E))	, / Z3	3195.000	
					en de la composition br>La composition de la	
C1PS=C16*Z4/Z	(2			₹ 👰	53.250	
C kC I =C I	ra X,K			OF POOR	3.550	
3U = M303	M OK CTO*Z5/ZZ/	ENYK		2	1.775	
COMMENTS				PHART		
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1.4 GROUND RECEIVING STATION

The ground receiving station (GRS) is designed to accept power from a single satellite and to provide a nominal 5 GW of power to the utility interface. As shown in Figure 1.4-1, a typical receiving station would be located at 34° N latitude with rectenna panels covering an elliptical area of 13 km in the north-south direction and 10 km in the east-west direction. This area is surrounded by another elliptical segment to house the power conversion equipment and to provide for the operational facilities of the receiving station. A summary of point design characteristics are presented in Table 1.4-1.

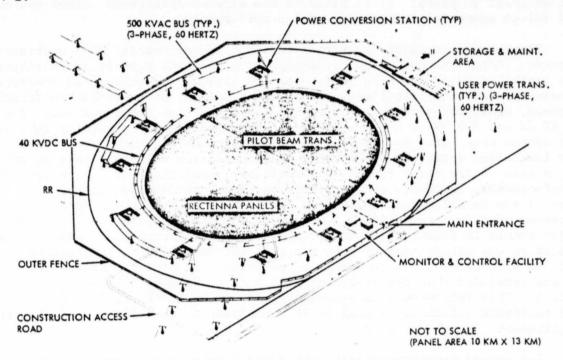


Figure 1.4-1. Operational Ground Receiving Facility (Rectenna) - Typical

Table 1.4-1. System Point Design Characteristics

SIZE (km)	10×13
TOTAL GROUND AREA (km) 2	102.1
TOTAL PANEL AREA (km) 2	79.53
AREA PER PANEL (9.33×14.69 m)	137.0
NUMBER OF PANELS	580,500
NUMBER OF DIODES	330×106
RECTENNA EFFICIENCY (%)	89
VOLTAGE OUTPUT PER STRING (kV dc)	40+
VOLTAGE OUTPUT TO UTILITY (kV ac)	500
POWER OUTPUT (GW) AT UTILITY INTER-TIE	4.61*

ORIGINAL PAGE IS OF POOR QUALITY This ground based element of the SPS is comprised of the land, facilities, equipment, and hardware/software systems to receive the radiated microwave power beam and to provide the power at the required voltage and type of current for entry into the national power grid. It also includes the equipment, facilities, and hardware/software necessary to provide operational control over the satellite; and a reliable means of monitoring and controlling ground based systems and equipment.

Major objectives of the SPS ground system design are: (1) to provide low maintenance subsystems and equipment capable of handling the designed power levels; (2) to assure that the overall station will provide dependable service for at least 30 years; (3) to minimize the size of operational crews and costs; and (4) to economically optimize system performance.

There are nine major activities involved in the overall GRS construction process. After the survey and clearing, utilities and supporting facilities are installed while the site is leveled and graded. Trenching and concrete pouring precede the installation of rectenna panels, after which electrical hook-up, converter stations, and monitoring facilities are installed. The 40 kV dc and 500 kV ac buses are then interconnected and procedures take place for system checkout. Cost effective utilization of equipment and personnel was identified after the development and integration of detail phasing schedules on each of the first four ground stations. Contacts with A&E, equipment manufacturers, concrete, and construction firms provided additional information on the duration and sequence of operations based on their experience with programs of this type. Figure 1.4-2 is an integrated summary schedule of major events in constructing the ground receiving station where emphasis is placed on the utilization of construction equipments and their transfer from site to site as required to maintain the build rate of two stations per year. It was concluded that the equipment from Site 1 would be available for use on Site 3. This information on equipment/manpower utilization, site sequencing, and equipment lifetimes is used in this analysis to establish total resource requirements for the program.

The ground receiving station was divided into several main elements for the purpose of associating cost and programmatic definitions. These elements include (1) site and facilities, (2) rectenna support structure, (3) power collection, (4) control, (5) grid interface, and (6) operations. SPS design definitions and specification requirements were analyzed to provide realistic cost estimates and resource definitions for each element as explained in the following sections.

Internal resources, cost estimating relationships, and prior cost analyses were supplemented by: 1) direct contact with business, industry, and institutional organizations, and 2) a literature search of various publications to obtain realistic cost estimates and operational definitions directly applicable to the unique requirements of the GRS. A list of principal organizations and literature sources are presented in Table 1.4-2.

A summary of the costs associated with the GRS is presented in Table 1.4-3. The detail supporting these costs is presented in the subsequent pages of this section.

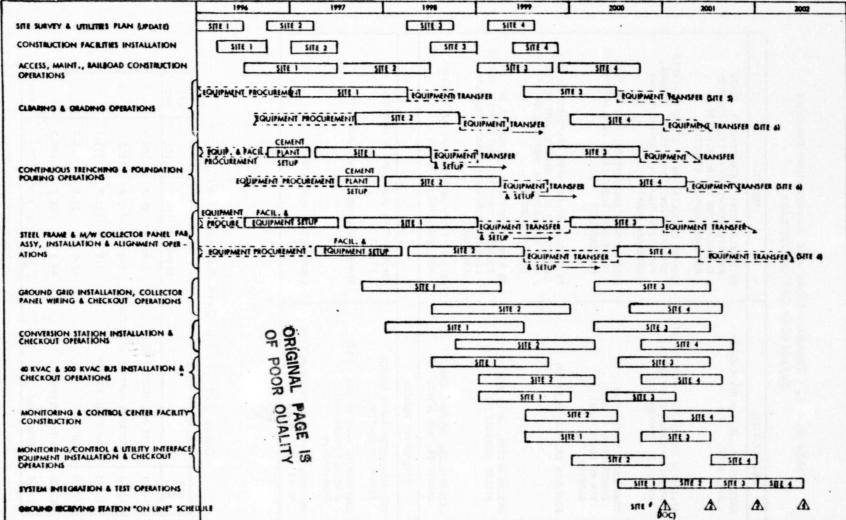


Figure 1.4-2. Rectenna Construction Sequence Summary Schedule



Table 1.4-2. Organizations and Literature Sources Supporting GRS Definition

ORGANIZATION	PURPOSE
AMERICAN BRIDGE - A DIVISION OF U.S. STEEL	TO DEVELOP STEEL REQUIREMENTS, COSTS AND OPERATIONS DEFINITION FOR PRO- CUREMENT AND INSTALLATION OF RECTENNA SUPPORT STRUCTURE
• RIVERSIDE CEMENTA DIVISION OF AMERICAN CEMENT CORPORATION; AND C. S. JOHNSON, CO.	PROVIDE CONSULTATION ON CEMENT/CONCRETE SPECIFICATIONS, OPERATIONAL METHODS, PROCESSING/HANDLING EQUIPMENT, AND CONCRETE PLANT
• TOWNSEND & BOTTUM, INC., CONSTRUCTION MANAGER, TEN MW SOLAR PLANT - BARSTOW, CA.	DISCUSS SITE PREPARATION, CONSTRUCTION OPERATIONS/SEQUENCING, PLUS ACTIVATION REQUIREMENTS
• SOUTHERN CALIFORNIA EDISON	TO DISCUSS DC/AC POWER DISTRIBUTION AND CONVERSION REQUIREMENTS, AND OBTAIN COST ESTIMATES ON INSTALLATION OF LINES/TOWERS
• MODERN ALLOYS, INC.; AND MILLER FORMLESS CO.	TO DISCUSS USE AND APPLICATION OF EQUIPMENT/CREW FOR CONTINUOUS CONCRETE POUR OF RECTENNA SUPPORT STRUCTURE FOOTINGS
 CATERPILLAR; INTERNATIONAL HARVESTER; AND JETCO, INC. 	OBTAIN PRICES ON EARTH MOVING, GRADING AND TRENCHING EQUIPMENT
LITERATURE SOURCES	
• THE RICHARDSON RAPID SYSTEM 1978-1979 EDITION	CONSTRUCTION LABOR AND OPERATIONS PRICES
ENGINEERING NEWS RECORD - 1977 A WEEKLY McGRAW-HILL PUBLICATION	CEMENT, AGGREGATE AND LABOR PRICES
NATIONAL CONSTRUCTION ESTIMATING GUIDE (NCE)	CONSTRUCTION OPERATIONS

Table 1.4-3. GRS Cost Summary (\$ Millions)

WBS NO.		DDT&E	TFU	101	RCI/ O&M
1.4.1	SITE AND FACILITIES	1.0	195.2	188.9	.2
1.4.2	RECTENNA SUPPORT STRUCTURE	2.0	1849.6	1828.	.5
1.4.3	POWER COLLECTION	3.0	1353.2	1353.2	-
1.4.4	CONTROL	10.0	75.0	75.0	-
1.4.5	GRID INTERFACE	99.7	145.7	145.7	· <u>-</u>
1.4.6	OPERATIONS	-	-	-	77,9

1.4.1 SITE AND FACILITIES

The ground receiving station is located on a site of 35,000 acres where over 25,000 acres of a central ellipse, or 72% of the total acreage, is used for rectenna panels. The area surrounding the inner ellipse is allocated for maintenance/control facilities, access roads, converter stations, and the rows of towers that support the $40~\rm kW$ dc and $500~\rm kV$ ac cables. The GRS perimeter is fenced for security reasons.

The sequence of construction operations begins with site identification, environmental impact studies, zoning/permits, surveys, utility/road installation, and supporting facilities. After reference coordinates are established, the site is cleared, leveled, and followed with precise grading for panel foundations, fabrication facilities, installation and GRS site completion. This includes concrete mixing plants, rectenna panel fabrication factories, crew accommodations, warehousing, and support facilities as shown in Figure 1.4-3. The GRS DDT&E effort will be a valuable asset to all GRS sites by providing designs, analyses, and procurement specifications for commonly used buildings and facilities.

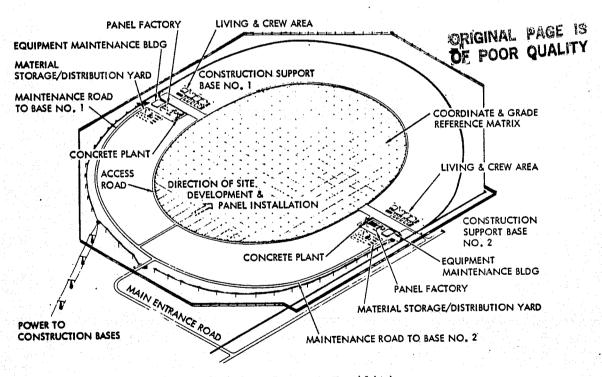


Figure 1.4-3. Support Facilities

Clearing and leveling operations will occur at a number of locations within the panel farm perimeter. These operations consist of tree removal (if required), grading, and leveling the terrain to acceptable slope angles, and removing excess dirt. Sixteen areas of the ellipse would be cleared and leveled simultaneously. Bulldozers will make the initial cut, scrapers will grade to more precise requirements, and an estimate was made of one crew of 13 men

to grade eight acres per day. The crew and equipment required to prepare a 35,000 acre site was established based on a single shift that would level 130 acres per day to meet a nine month schedule.

Costs developed for the site and facilities are divided into the elements of land, site preparation, roads and fence, utilities, buildings and facilities, maintenance equipment, lightning protection, and DDT&E. Basic design parameters used in this costing are presented in Table 1.4-4. The DDT&E, investment, and operations cost established for each element are tabulated as follows:

Table 1.4-4. Site and Facilities Requirements

ITEM	UNIT PARAMETER
LAND/FENCING	35,000 ACRES
GRADING/LEVELING	HEAVY EQUIPMENT/CREW SIZE
PREPARATION	SURVEY, EIR, PERMITS, ASE PLANNING
UTILITIES	WATER, ELECTRICITY, GAS, SEWAGE
ROADS/RAILS	ROADS 35 MILES; RAILS 45 MILES
FACILITIES	CONVERSION STATION, MONITOR & CONTROL, MAINTENANCE/STORAGE
DRAINAGE	6" GRAVEL FOR COMBINATION ACCESS- WAY & DRAINAGE BETWEEN PANEL ROWS
LIGHTNING PROTECTION	TBD

Table 1.4.1.1 Land and Preparation (Land - 1.4.1.1.1, Preparation -1.4.1.1.2Table 1.4.1.2 Roads and Rences (Rails & Roads - 1.4.1.2.1, Fencing -1.4.1.2.2) Table 1.4.1.3 Utilities Buildings and Facilities (Storage/Maintenance - 1.4.1.4.1, Table 1.4.1.4 Converter Station - 1.4.1.4.2) Table 1.4.1.5 Maintenance Equipment Table 1.4.1.6 Lightning Protection System Site & Facilities DDT&E Table 1.4.1.7

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.4.1.1.1 LAND

	INPU	T PARAMETERS			INPUT	COEFFICIENTS	
	T= 35000.0000 M= 35000.0000 CF= 1.00000 PHI= 1.00000	00 Z1= 00 Z2=	1.000000 0.0 1.000000 60.000000		CDCER = CDEXP = CICER = CIEXP =	0.0 0.0 0.001000 1.000000	
	R= 0.0 DF= 1.00000	Z3= 00 Z4=	60.000000 60.000000	25 =	0.0		
	CALCULATED VALUES	ACRES	SUM TO	1.4.1.1	The second se	\$,MILLIONS	
	CD=CDCER X (T X DF)XX(CD	EXP) X CF		·	را نقال در استان در استان از را در	0.0	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF				35.000	
B-2	#RM =T / M					1.000	
251	E =1.0 + LOG(PHI) / LO	G(2.0)				1.000	er er grande en
	CTFU=(CLRM / E)X((#RM X	Z1+.5)XX(E) -0	.5XX(E))			35.000	
	CTB = ((CLRM/E)X((#RM X	Z3 + 0.5)XX(E) -0.5XX(E))) / Z3	35.000	
	CIPS=CTB*Z4/Z2	an languaga da gangalan sa	anan ing panangan ang at ting	race na ar constitue esa r	· · · · · · · · · · · · · · · · · · ·	35.000	and the second s
	CRCI =CTB X R				POOR	0.0	
	CO&M = O&M OR CTB*Z5	/Z2/ENYR			QUALITY	0.0	
	COMMENTS				7:		

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.4.1.1.2 LAND PREPARATION

	INPUT PARAMETERS		IN	PUT COE	FFICIENTS	
	T= 35000.0000 TF=	1.000000	CDCER=		0.0	
	M= 35000.0000 O&M=	0.0	CDEXP=		0.0	
	CF= 1.000000 Z1=	1.000000	CICER=		0.002007	
	PHI= 0.980000 Z2=	60.000000	CIEXP=		1.000000	
	R= 0.0 Z3= DF= 1.000000 Z4=	60.000000 60.000000	25=	0.0		
	1.00000 24-	00.000000	25-	0.0		
	CALCULATED VALUES ACRES	SUM TO 1	.4.1.1		\$, MILLIONS	
	CD=COCER X (T X DF)XX(CDEXP) X CF	and the second s	e de la companya del companya de la companya del companya de la co	and the second second	0.0	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF				70.245	
В	#RM =T / M				1.000	
252	E =1.0 + LOG(PH2) / LOG(2.0)				0.971	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.	5XX(E))			70.341	
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / Z3		64.119	
	CIPS=CTB*Z4/Z2		المراجعية br>المراجعية المراجعية		64.119	e e e e e e e e e e e e e e e e e e e
	CRCI =CTB X R				0.0	
	COEM = OEM OR CTB*Z5/Z2/ENYR				0.0	
	COMMENTS					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.1.2.1 RAILS AND ROADS

	INPUT PARAMETERS			الداعية المستوالية المساور الما المستوالية المارية. المارية المستوالية المستوالية المستوالية المارية المارية المارية المارية المستوالية المستوالية المستوالية الم	INPUT COEFFICIENTS					
	T= M= C F= PH I=	1.000000 1.000000 1.000000 1.000000	TF= O&M= Z1= Z2=	1.000000 0.0 1.000000 60.000000		CDCER= CDEXP= CICER= CIEXP=		0.0 0.0 73.710007 1.000000		
	R= DF=	0.0 1.000000	Z3= Z4=	60.000000 60.000000	Z5 =		0.0			
		TED VALUES	SET	SUM TO	1.4.1.2			\$,MILL	IONS	
***		T X DF)XX(CDEXP (M)XX(CIEXP) X						73.710		
B-253	#RM =T / M E = 1.0 + L	.0G(PHI) / L0G(2	•0)					1.000 1.000		
	CTFU=(CLRM /	' E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))				73.710		
	CTB = ((CLRM/	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		73.710		
	CIPS=CTB*Z4/					9 9		73.710 0.0		
		DEM OR CTB*Z5/Z2	/ENYR			POOR		0.0		
	COMMENTS					PAGE				
					***************************************	₹ 5				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.1.2.2 FENCING

		INPUT P	ARAMETERS			IN	PUT COEF	FICIENTS	
	Te	42671.0000	TF=	1.000000		CDCER=		0.0	
	M=	42671.0000	=M30	0.0		CDEXP=		0.0	
	C F=	1.000000	Z1=	1.000000	•	CICER=		0.000011	
	PHI=	0.980000	Z2=	60.000000		CIEXP=		1.000000	Canada and
	R=	0.0	Z3=	60.000000					
	DF=	1.000000	Z 4 =	60.000000	Z5 =		0.0		
	CALCUL	ATED VALUES	M	SUM TO 1.	4.1.2		·	\$, MILLIONS	- A CONTRACTOR OF THE STATE OF
	CD=CDCER X	(T X DF)XX(CDEXP) X CF					0.0	
	CLRM=CICER	X (M)XX(CIEXP)	CF X TF					0.469	
ᄪ	#RM =T / M							1.000	
B-254	E =1.0 + LOG(PHI) / LOG(2.0)							0.971	
	CTFU= (CLPM	/ E)X((#RM X Z1+	.5)XX(E) -0.	5XX(E))				0.470	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z3		0.428	
	CIPS=CTB*Z4	/72						0.428	
	CRCI =	CTB X R		-				0.0	
	CO&M =	O&M OR CTB*Z5/Z2	∕ ENYR					0.0	
	COMMENTS							なからから世界があり。 Linux in the Linux in the Alexander	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.1.3 UTILITIES

INPUT PARAMETERS		INPUT COEFFICIENTS				
	T= 1.000000 TF= M= 1.000000 O&M= CF= 1.000000 Z1= PHI= 1.000000 Z2= R= 0.0 Z3= DF= 1.000000 Z4=	1.000000 0.0 1.000000 60.000000 60.000000	CDCER = CDEXP= CICER = CIEXP=	0.0 0.0 0.200000 1.000000		
	CALCULATED VALUES SET CD=CDCER X (T X DF)XX(CDEXP) X CF	SUM TO 1	.4.1	\$, MILLIONS 0.0		
	CLRM=CICER X (M)XX(CIEXP) X CF X TF			0.200		
) - -	#RM =T / M E = 1.0 + LOG(PHI) / LOG(2.0)			1.000		
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -	0.5XX(E))		0.200		
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX	((E) -0.5XX(E))	1698	0.200		
	CIPS=CTB*Z4/Z2 CRCI =CTB X R		1 / (4)	0.200		
	CO&M = O&M OR CTB*Z5/Z2/ENYR			0.0		
	COMMENTS					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.1.4.1 STORAGE, MAINTENANCE

		INPUT	PARAMETERS			INPUT CO	EFFICIENTS	the second of the second of the second of
	Τ=	1.000000	TF=	1.000000		CDCER=	0.0	
	M=	1.000000	=M30	0.0		CDEXP=	0.0	
	CF=	1.000000	Z 1 =	1.000000		CICER=	1.300000	
	PH I=	1.000000	Z2=	60.000000		CIEXP=	1.00000	
	R=	0.0	Z3=	60.000000	erite residente e i ripatio acarrologico i	And the second s		
	DF=	1.000000	Z 4=	60.000000	Z5 =	0.0		
	CALCUL	ATED VALUES	\$	SUM TO 1.	4.1.4		\$, MILLIONS	
	60 60650 4	47 N DEANNESSEN						
	CD=CDCER X	(T X DF)XX(CDEX	(P) X CF				0.0	
	CLOM-CICED	X: (MI)XX-(CIEXP)	V CC V TC		n sager en			
	CERH-CICER	A UNIXACCIEARI	A CF A IF				1.300	
- ta -	#RM =T / M						1.000	
25	7,100						1.000	
9	E = 1.0 +	LOG(PHI) / LOG(2.0)				1.000	
			The second secon	According to agree a quadratical according to the same of the same of	mental production and a	Carrier Company (1994)		
	CTFU=(CLRM	/ E)X((#RM X Z1	+.5)XX(E) -0).5XX(E))			1.300	
	den Staare den sits i middelen menangan maken en in sit is is	The State of the S		e en l'an entre une en annoire le residence de l'annoire de l'annoire de l'annoire de l'annoire de l'annoire de			allementari er eretari kaleman eretari	
	CTD -//CLDM	/E1V//4DM V	72 . 0 . 51.444	5)				
	CID - (CERM	/E)X((#RM X	73 + 0.01XXI	E1 -0.5XX(E11) / Z3	1.300	
	CIPS=CTB*Z4	172		er en			1.300	
							1.300	
	CRCI =	CTB X R					0.0	
					· · · · · · · · · · · · · · · · · · ·			
	= M303	O&M OR CTB*Z5/Z	2/ENYR				0.0	
	COMMENTS							
	COMMENTS							

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.1.4.2 CONV. STA. & MONITOR/CONTROL FAC.

INPUT PARAMETER	INPUT PARAMETERS			
T= 21290.0000 TF=	1.000000	CDCER =	0.0	oden og produktiva og storet er en
M= 21290.0000 0&M=	0.0	CDEXP=	0.0	
CF= 1.000000 Z1=	1.000000	CICER=	0.000478	
PHI= 1.000000 Z2=	60.000000	CIEXP=	1.000000	an ang managan ang managan sa katang m Managan katang managan sa katang manag
R= 0.0 Z3= DF= 1.000000 Z4=	60.000000 60.000000	Z5 = ().0	
1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	80.000000	<i>L</i>)-	5.0	
CALCULATED VALUES SQ M	SUM TO	1.4.1.4	\$, MILLION	NS .
CD=CDCER X (T X DF)XX(CDEXP) X CF			0.0	
CLRM=CICER X (M)XX(CIEXP) X CF X TF			10.177	
#RM =T / M			1.000	
E =1.0 + LOG(PHI) / LOG(2.0)			1.000	
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E)	-0.5XX(E))		10.177	
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)	XX(E) -0.5XX(E))) / Z3	10.177	
CIPS=CTB*Z4/Z2			10.177	
CRCI = CTB X R		99	0.0	
COEM = OEM OR CTB*Z5/Z2/ENYR		OF POOR	0.0	
COMMENTS		9 P		** ************************************
COMPLIES.				
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		3	.	
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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.1.5 MAINTENANCE EQPT.

	INPUT PARAMETERS			INPUT COEFFICIENTS				
		1.000000	TF=	1.000000	CDCER =		0.0	
	M=	1.000000	=M30	0.0	CDEXP=		0.0	
	CF=	1.000000	Z 1 =	1.000000	CICER=		4.000000	
	PHI=	1.000000	Z2=	60.000000	CIEXP=		1.000000	
	R≠	0.050000	Z3=	60.000000				
	DF=	1.000000	7.4=	60.000000	25 =	0.0		
	CALCULAT	ED VALUES	\$	SUM TO 1.	%.1		\$.MILLIONS	
	CD=CDCFR X (T	X DF)XX(CDEXP) X CF				0.0	
	CLRM=CICER X	(M)XX(CIEXP) X	• · · · · · · · · · · · · · · · · · · ·				4.000	
	#RM =T / M						1.000	
258	E =1.0 + LO	G(PHI) / LOG(2	.0)				1.000	
	CTFU=(CLRM /	E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			4.000	
	CTB = ((CLRM/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))) / Z:	3	4.000	
	CIDC-CTD+1//7						4 000	
	CIPS=CTB*Z4/Z	4					4.000	
	CPCI =CT	B X R		aran a ka mata aya ka mata aya ka mada	g.		0.200	ي الإرسيد المارية
	COEM = OE	M OR CTB*Z5/Z2	/ENYR				0.0	
	COMPLICATION							

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.1.6 LIGHTNING PROTECTION

	TABLE								
,		INPUT P	ARAMETERS		المحمد المعمولات الموسوسة المحمد المحمولات الموسوسة المحمولات المحمولات المحمولات المحمولات	INP	UT COEFFICIENT	S	Commission with the commission of the commission
	T=	0.0	TF=	1.000000		CDC ER =	0.0		
	M= C F= PH I=	0.0 0.0 1.000000	0&M= Z1= Z2=	0.0 1.000000 60.000000		CDEXP= CICER= CIEXP=	0.0 0.0 0.0		
	R= DF=	0.0 1.000000		60.000000 60.000000			0.0		
		ED VALUES X DF)XX(CDEXP	\$) X CF	SUM TO	1.4.1			\$,MILLIONS	
	CLRM=CICER X	(M)XX(CIEXP) X	CF X TF					0.0	
B-2	#RM =T / M						0.0		
.259	E = 1.0 + LO	G(PHI) / LOG(2	.0)			· · · · · · · · · · · · · · · · · · ·	0.0		and the second section of the second section is a second section of the second section
	CTFU=(CLRM / I	E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))		<u></u>		0.0	J. Wall
	CT8 = ((CLRM/E)X((#RM X Z	3 + 0.5)X	(E) -0.5XX(E))) / Z3		0.0	
	CIPS=CTB*Z4/Z	2	a value ta que e el como en tana	ere ere er er e r er /del>		ere en magazine. Le sai de magazine sant i com	and an include the contract that granteen department and the property of the	0.0	negative productive and the second se
	CRCI = CTI	B X R			,			0.0	
	130 = M3D3	M OR CT8*Z5/Z2	/ENYR					0.0	A PARTY TO THE PAR
	COMMENTS					ORIGINAL OF POOR			
						PAGE 13			

RM=CICER X (M)XX(CIEXP) X CF X TF						
		MIION				
TABLE 1.4.1.7 SITE & FACILI	TIES DOTAE					
INPUT PARAMETERS			ĪN	PUT COEF	FICIENTS	
				· .		
CF= 1.000000 Z1=	1.000000		CICER=		0.0	
그는 그들이 하나 하다는 것이 없는 것이 없는 것이 없었다.				0.0		
CALCULATED VALUES \$	SUM TO 1.4	to I	<u> </u>		\$, MILLIONS	
CD=CDCER X (T X DF)XX(CDEXP) X CF					1.000	
CLRM=CICER X (M)XX(CIEXP) X CF X TF					0.0	
#RM = T / M					1.000	
E =1.0 + LOG(PHI) / LOG(2.0)		And the second s	و د د د د د د د د د د د د د د د د د د د		1.000	monanten a control description for the seminary
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -	0.5XX(E))				0.0	
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX	(E) -0.5XX(E))) / Z3		0.0	
CIPS=CT8*Z4/Z2	ستند سند هر سستن سدد در بیاست در	. 	arianisan and a second		0.0	Conservation of the desire give a magnetic .
CRCI =CTB X R					0.0	

0.0

COMMENTS

COEM = DEM OR CTB*Z5/Z2/ENYR

1.4.2 RECTENNA SUPPORT STRUCTURE

The rectenna farm area of $102.1~(km)^2$ is covered by 580,500 panels that have a total mW intercept area of $79.53~(km)^2$. Each panel $(9.33~m\times14.69~m)$ is tilted at an angle of 40° to the horizontal and is mounted on two continuous ribbons of concrete as shown in Figure 1.4-4. The procurement, fabrication, assembly and installation of the steel rectenna support structure, and the supporting foundation placement are costed in this section and represent the results of consultation and discussions with industrial/construction contacts.

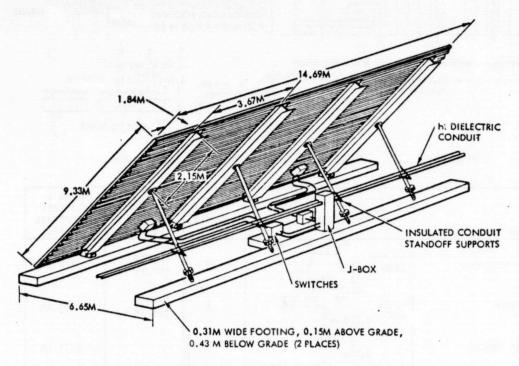


Figure 1.4-4. Panel Installation

1.4.2.1 PANEL STRUCTURE

The rectenna panel structure is comprised of four standard size eightinch (wide flange) I beams, supporting tube braces, and 18 hat-shaped sections for the mounting of the power collection electronic elements. Tube braces, steel cast fittings and attachment hardware are used to support the panel on the continuous footing as shown in Figure 1.4-5.

A detail analysis of the support structure was completed to identify the amount of material needed; fabrication, operations, assembly, and installation requirements; plus an estimate of manpower and equipments needed to produce the average daily production of 2150 panels over the nine month period. The cost of material for a rectenna panel is shown in 1.4-6.

The rectenna panel hat section serves as a mounting surface for the laminated-copper-clad mylar array elements. (See section 1.4.3, Power Collection). Adhesives will be used to mount the elements to the structure to

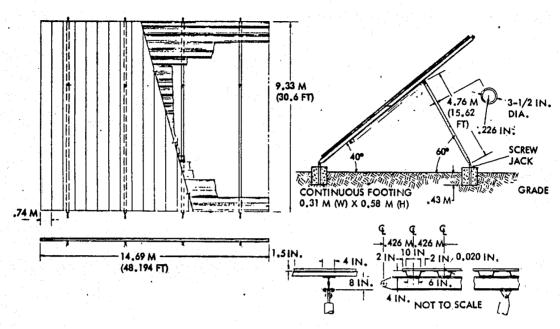


Figure 1.4-5. Rectenna Array Support Structure

ITEM/DESCRIPTION	DIMENSIONAL DATA	NUMBER REQ'D	TOTAL WEIGHT	PREFAB & DELIVERED COST/PANEL (DOLLARS)
HAT SECTIONS	14.69M 4"	18	1288# 584.25 kg	\$618.24
I-BEAMS	9.33M 3.94" LONG 0.170 7.90"	4	1589# 720.75 kg	\$508.48
TUBE BRACES	0.204	4		\$773.76
HARDWARE FITTINGS & WELDING ROD	4.76M — 0.226" LONG — - 3.50"	4 SETS	1104# 500.75 kg	
RETURNED SCRAP ALLOWANCE			-307# -139 kg	\$30.70
TOTAL MATERIAL PER PANEL			3674# 1666.75 kg	\$1869.78

Figure 1.4-6. Rectenna Panel Support Structure

provide continuous support and added strength with a minimum of localized panel deflection.

The basic hat section is formed at the rectenna site from 0.020" galvanized steel sheet stock by processing through a set of forming rollers in a continuous manner. The forming machine (Yoder mill) accommodates widths of rolled mill stock sufficient to produce the finished hat sections ready for assembly to the I-beams.

Four standard wide-flange 8-inch galvanized steel I-beams are required in lengths of 9.33 m for each rectenna panel. This material will be delivered to the site in precut lengths for hole punching and the addition of brackets/machined castings for the support braces and panel mounting.

Four 3.5" diameter tube braces of galvanized steel are cut to a length of 4.76 m and preassembled to the fittings/hardware. Anchors, brackets, clips, hangers, etc., are fabricated or cast of carbon steel material and galvanized prior to machining at the site. All these items are scheduled to combine with the hat sections and I-beams at a centralized facility for assembly. A concept for such a facility is shown in Figure 1.4-7. The factory has multiple assembly lines where each line has a materials feed section, steel assembly facilities, electron ics assembly and checkout section. It was assumed that one line using automated procedures could assemble and checkout a panel in 40 minutes. On this basis, seventy-two assembly lines operating 20 hours per day, seven days a week are required to produce 580,500 panels in the allocated 270 days. Eight additional requirements are summarized in the lower left of the figure.

After the panels have been checked, they are placed on an overhead conveying system and transported to loading stalls, where they are assembled into 9-panel magazines and loaded on specially designed trucks for delivery to the point of installation.

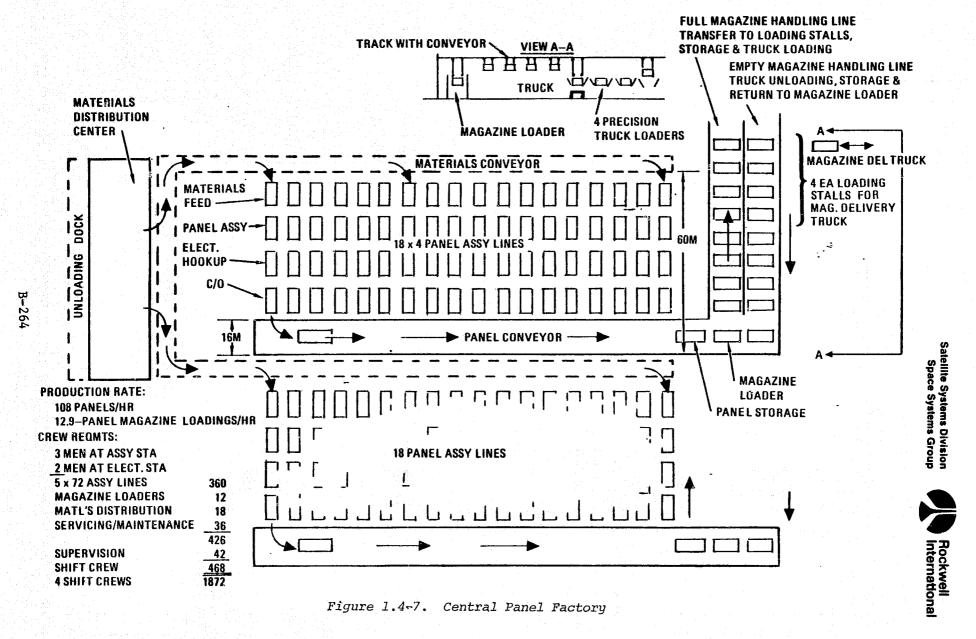
Specialized equipment is required to deliver the panels from the factory to the installation point and to install them because of their large dimensions. After consultation with industrial sources on large equipment handling, a concept for a specialized machine was developed (Figure 1.4-8). The front and rear wheel pairs are each steerable as a unit and have provisions for height adjustment. The panels are transferred in magazines and lifted by means of fixtures mounted in vertical rails. They can be translated laterally and longitudinally for final positioning before attachment to the footings.

1.4.2.2 TRENCHING AND CONCRETE FOOTINGS

A trade-off which considered eight individual footings versus continuous footings was made. A maximum wind force of 90 m/hr was assumed. It was determined that the amount of concrete required for either approach was essentially the same, but that the continuous footing concept was easier to install and required fewer operations and less capital equipment.

Each panel is secured to the footings at eight locations by fixtures which are imbedded in the concrete during the pouring operation. Mounting attachments which provide for longitudinal and lateral adjustment are secured to the fittings. Screw jacks on each of the rear attach points provide for panel adjustment and alignment.

The footings of continuous concrete are 0.43 meters deep, 0.31 meters wide, and project 0.15 meters above ground level. Two footings are excavated simultaneously by trenchers which feed the removed dirt into a truck. Approximately 17×10⁶ meters of trenches must be excavated. To accomplish this, 38 trenchers are required, each trencher excavating 90 meters per hour.



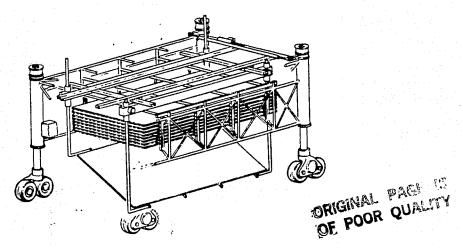


Figure 1.4-8. Panel Loading Sequence

Table 1.4-5 summarizes crew and equipment requirements compatible with the nine month schedule to prepare 1088 panel rows per rectenna.

Table 1.4-5. Concrete Footing Equipment/Crew

ITEM/DESCRIPTION	SITE CONSTRUCTION QUANTITY	1977 UNIT PRICE (DOLLARS)	TOTAL COST
TRENCHERS - JW-2	38	\$70,000	\$2,660,000
DUMP TRUCKS - 992C	26	\$350,000	\$9,100,000
CONCRETE DELIVERY VEHICLES - 10 C.Y.	190	\$50,000	\$9,500,000
CONCRETE FORMING MACHINES	10	\$60,000	\$600,000
CONCRETE CENTRAL MIX PAVING PLANTS	2	\$250,000	\$500,000
TOTAL COST			\$22,360,000
TRENCHING & CONCRETE CREW PERSONNEL	1480		

Each rectenna panel will be mounted and aligned on 6.8 cu yds of concrete placed by concrete formers such as those commonly used in freeway divider construction. The formers extrude a shaped ribbon at rates of 6 meters per minute. Reinforcing steel and panel attach fittings are inserted as the concrete is vibrated during the extrusion process. Concrete footing requirements for the rectenna panels are shown in Table 1.4-6.

Table 1.4-6. Concrete Footing Requirements

ITEM/DESCRIPTION	1977 \$ (MILL PRICE Delivered)	INGREDIENTS FOR 6.8 CU.YDS.	MATERIAL COST DELIVERED (1977 DOLLARS)
CEMENT (5 SACK) (94# SACK)	\$42/TON	3196#	\$67.12
SAND	\$4.51/TON	9520#	\$21.47
ROCK 1"-111"	\$4.39/TON	12444#	\$27.31
WATER		2040#	Ø
REINFORCING STEEL - #4	\$0.10/LB	64#	\$6.44
TOTAL/PANEL		27264#	\$122.34

DELIVERED 1977 MILL PRICES PER ENGINEERING NEWS RECORD (ENR) - McGRAW HILL, AN INDUSTRY PUBLICATION

1.4.2.3 COST ESTIMATES

DDT&E, investment, construction/installation, and operations costs of the rectenna support structures (less electronic elements) and the concrete footings are identified in the following tables:

Table 1.4.2.1.1	Hat Sections
Table 1.4.2.1.2	Wide Flanges
Table 1.4.2.1.3	Tube Braces & Hardware
Table 1.4.2.1.4	Assembly & Installation
Table 1.4.2.2.1	Footing Concrete & Rebar
Table 1.4.2.2.2	Machinery & Equipment
Table 1.4.2.2.3	Construction Operations
Table 1.4.2.3	Support Structure DDT&E

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.2.1.1 HAT SECTIONS

	INPUT PARAMETERS				INPUT COEFFICIENTS		
†	580500.000	TF=	1.000000	CDCER=	0.0	•	
M=	1.000000	=M3O	0.0	CDEXP=			
CF=	1.000000	Z 1 =	1.000000	CICER=			
PH[=	1.000000	7.2=	60.000000	CIEXP=			
R=	0.0	Z3=	60.000000		an management was a management of the second		
0 F=	1.000000	Z4=	60.000000	Z5 =	0.0		
CALCI	ULATED VALUES	PANEL	SUM TO 1.	4 2 1	\$,MILLIO	INC	
CALC	SEATED VALUES	FANEL	3014 10 13	4.2.1	J YMILLIO	N43 .	
CD=CDCER	X (T X DF)XX(CDEX) X CF	and the second s		0.0		
CLRM=CICE	R X (M)XX(CIEXP)	CF X TF			0.001		
#RM =T / 1	Y				580500.000		
$\hat{G} = 1.0$	+ LOG(PHI) / LOG(2	2.0)		* · · · · · · · · · · · · · · · · · · ·	1.000	en e	
CTFU={CLR	M / E)X((#RM X Z1	5)XX(E) -0).5XX(E))		359.228		
CTB = ((CL	RM/E)X((#RM X Z	23 + 0.5)XX(E) -0.5XX(E))) / Z:	3 359.224		
CIPS=CTB*	74/72			anne de la la la constanta de /del> La constanta de la constanta d	9 359.224 POR 0.0	and the second s	
CRCI	=CTB X R				0.0		
	= O&M OR CTB*Z5/Z2	?/ENYR			0.0		
WITH (PANEL USES 18 HAT COST ESTIMATE(USS)		TALING 584.25 KG	(1288LBS)			
\$1.05	8/KG (\$.48/LB).	-	a	Mere 100 Mei Brian I, (p. 15 september 7 MF - Brisily (p. 16 september 16 septe			

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.2.1.2 WIDE FLANGES

Product car of		INPUT F	PARAMETERS			IN	PUT COEF	FICIENTS	e de la Caraca de L La Caraca de La Car
	T= M= CF= PH I=	580500.000 1.000000 1.000000 1.000000	TF= O&M= Z1= Z2=	1.000000 0.0 1.000000 60.00000		CDCER= CDEXP= CICER= CIEXP=		0.0 0.0 0.000508 1.000000	
	R= DF=	0.0 1.000000	Z3= Z4=	60.000000 60.000000	Z5 =		0.0		
	CALCUI	LATED VALUES	PANEL	SUM TO 1	.4.2.1			\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXE	X CF				· · · · · · · · · · · · · · · · · · ·	0.0	
	CLRM=CICER	X (M)XX(CIEXP)	CF X TF					0.001	
B	#RM =T / M						5	80500.000	·
268	E = 1.0 +	LOG(PHI) / LOG(2	.0)			-1	المراجع	1.000	
	CT FU= (CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))				295.173	
	CTB = ((CLR	M/E)X({#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3		295.170	
	CIPS=CTB*Z	4/Z2		· · · · · · · · · · · · · · · · · · ·				295.170	
	CRCI =	CTB X R						0.0	
	CORM =	OEM OR CTB*Z5/Z2	/ENYR					0.0	• • • • • • • • • • • • • • • • • • •

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.2.1.3 TUBE BRACES & HARDWARE

	INPUT PARAMETERS	•	INPUT COEFFICIENTS			
	T= 580500.000 TF= 1.000000 M= 1.000000 0&M= 0.0 CF= 1.000000 Z1= 1.000000 PHI= 1.000000 Z2= 60.000000		CDCER= CDEXP= CICER= CIEXP=		0.0 0.0 0.000743 1.000000	
	R= 0.0 Z3= 60.000000 DF= 1.000000 Z4= 60.000000	Z5 =		0.0		
	CALCULATED VALUES PANEL SUM TO 1.4 CD=CDCER X (T X DF)XX(CDEXP) X CF	.2.1			\$, MILL IONS 0.0	
	CLRM=CICER X (M)XX(CIEXP) X CF X TF			saagan o aan geleen sa an ¥	0.001	
ᅜ	#RM = T / M				580500.000	
B-269	E =1.0 + LOG(PHI) / LOG(2.0)				1.000	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))				431.346	
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) / 23		431.343	
	CIPS=CTB*Z4/Z2			OF POOR	431.343	•
	CRCI = CTB X R		·	_ 3 § _	0.0	
	CC&M = O&M OR CTB*Z5/Z2/ENYR				0.0	
	COMMENTS INCLUDES 4 TUBE BRACES 4.76M LONG, FRONT & REAR CLEVIS FITTINGS, CAST MOUNTINGS, WELD RG AND PROVIDES FOR OVERALL SCRAP ALLOWANCES.	D •		220		

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.4.2.1.4 ASSEMBLY & INSTALLATION

	INPUT PARAMETERS				INPUT COEFFICIENTS					
	Τ=	580500.000	TF=	1.000000		CDCER=	0.0			
	M=	1.000000	=M30	0.0		CDEXP=	0.0			
	C F=	1.00000	Z 1 =	1.000000	,	CICER =	0.001052			
	PH I=	1.000000	Z2=	60.000000		CIEXP=	1.000000			
	R=	0.0	Z3=	60.000000						
	DF=	1.000000	Z4=	60.000000	Z5 =		0.0			
	CALCU	LATED VALUES	PANEL	SUM TO	1.4.2.1		\$, MILL IONS			
	CD=CDCER X	(T X DF)XX(CDEXP) X CF				0.0			
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				0.001			
병	#RM =T / M						580500.000			
-270	E =1.0 +	LOG(PHI) / LOG(2	.0)				1.000			
	CTFU= (CLRM	/ E)X((#RM X Z1+	.5)XX(E)	-0.5XX(E))			610.762			
	CTB = ((CLR	M/E)X((#RM X Z	3 + 0.5)X	X(E) -0.5XX(E))) / Z3	610.757			
	CIPS=CTB*Z	4/22					610.756			
·	CRC I	=CTB X R				· · · · · · · · · · · · · · · · · · ·	0.0			
	CO&M =	O&M OR CTB*Z5/Z2	/ENYR				0.0			
	COMMENTS									

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.2.2.1 FOOTING CONCRETE & RE-BAR

	INPUT P	ARAMETERS		INPUT COE			EFFICIENTS		
T =	580500.000	TF≃	1.000000	C	DCER=		0.0		
M=	1.000000	=M30	0.0	C	DEXP=		0.0	المستحيدة المستحيدة المستحيدة المتحديدين المستحيدية المحيدين المستحرب ويراها المستحرب ويراها المستحرب	
C F=	1.000000	Z 1 =	1.000000	C	ICER=		0.000122	•	
PHI=	1.000000	Z 2=	60.000000	C	IEXP=		1.00000		
R=	0.0	Z3=	60.000000	and the control of th		e i da esta e a lemando mente al eman.	The second secon	The state of the s	
DF=	1.000000	74=	60.000000	25 =		0.0			
CALCUL	ATED VALUES	PANEL	SUM TO 1.	4.2.2			\$,MILLIO	NS	
CD=CDCER X	(T X DE)XX(CDEXP) X CF		· · · · · · · · · · · · · · · · · · ·			0.0		
CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					0.000		
					· ·				
#RM =T / M						58	0500.000		
E =1.0 +	LOG(PHI) / LOG(2	.0)	المنافلات منفأ فليسيب السنا والمسافأ بأنا أفاق مشاورت	والمتعارضين فالمتارضي		and the same of th	1.000	A CONTRACTOR OF THE PROPERTY O	
CTEU- (CLDM	/ F1V((JD1 V 71)	51VV/51 0	· EVVIELL				70 021		
C1 FU= (CLKM	/ E)X((#RM X Z1+	- DIXXIEI -).DXX(E)				70.821		
							· · · · · · · · · · · · · · · · · · ·		
CTR = LICIRN	4/E)X((#RM X Z	3 + 0-51XXI	E) -0.5XX(E))) / 23		70.820		
C.D. T.CEM	TO CONCEPTION A	.5 . 0.5///	CI OLSKALEII		, , , ,		10.020		
CIPS=CTB*Z4	4/72	daning per jajan an arawa	ومهامين ويعمل السادي ويستواد	ما و م أمشو عوال الرائع الم		سلوسيون كالمتا	70.820	e a company a series and a series of the company and the compa	
							101020		
CRCI =	CTB X R						0.0		
						Marketta a Say a Say. La sa			
CC&M =	O&M OR CTB*Z5/Z2	Z/ENYR					0.0		
COMMENTS	and the second of the second o					and the second second		en e	
CCNCRET	TE ESTIMATED AT 6	. B CU YDS C	F 5 SACK CEMENT.						
	96 LBS CEMENT. 95) 🛊 de la companya di kacamatan di kacamata						
12444 1	BS 1-1.5 INCH RO	CK.	- BET James Miner Miner (E. 1877) - 1882 - Miner Spiller Miner Spiller Spiller Spiller Spiller Miner Spiller S			k tekni _g a objek alandansky miteria kt i 1981 – Leise	tiete en	Principality of the Company in Company and Charles and Company the Company of the	
								في	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.2.2.2 MACHINGERY & EQUIPMENT

		INPUT P	ARAMETERS		I NPUT C	DEFFICIENTS			
		1.000000	TF=	1.000000	CDCER=	0.0			
	M=	1.000000	=M3O	0.447200	CDEXP=	0.0			
	CF=	1.000000	Z 1 =	1.000000	CICER=	22.360001			
**	PHI=	1.000000	Z 2=	60.000000	CIEXP=	1.000000	and the second of the second particles and the second of t		
	DF=	0.003333 1.000000	23= 24=	8.000000 2.00000	Z5 = 0.0				
		1.000000	4. T	2.000000	27-				
	CALCULA	TED VALUES	SET	SUM TO 1.4.	.2.2	\$, MILLIONS			
	CD=CDCER X	T X DF)XX(CDEXP) X CF			0.0			
	CLRM=CICER >	((M)XX(CIEXP) X	CF X TF			22.360			
ᅲ	#RM =T / M					1.000			
.272	E =1.0 + L	.OG(PHI) / LOG(2	1.000						
	CTFU= (CLRM /	RM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))			22.360				
	CTB =((CLRM)	'E)X((#RM X Z	3 + 0.5)XX	(E) -0.5XX(E))) / Z3	22.360			
****	CIPS=CTB*Z4/	722	and the second s			0.745			
	CRCI =0	TB X R				0.075			
	C C&M = C	16M OR CTB*Z5/Z2	/ENYR			0.447			
***	COMMENTS								
)									

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.2.2.3 CONSTRUCTION OPERATIONS

	INF	UT PARAMETERS			INP	UT COEFFICIENTS	- War and Target To the Control of t
	T= 399600.000 M= 399600.000 CF= 1.0000 PHI= 1.0000 R= 0.0 DF= 1.0000	000 Z2= Z3=	1.000000 0.0 1.000000 60.000000 60.000000 60.000000	Z5 =	CDCER = CDEXP = CICER = CIEXP =	0.0 0.0 0.000150 1.000000	a decision and dependent
	CALCULATED VALUES CD=CDCER X (T X DF)XX(C CLRM=CICER X (M)XX(CIE)		SUM TO 1	.4.2.2		\$, MILL IONS 0.0 59.940	
B-273	#RM =T / M F =1.0 + LOG(PHI) / L	.06(2.0)				1.000	
	CTFU=(CLRM / E)X((#RM X	Z1+.5)XX(E) -	0.5XX(E))			59.940	
	CTB = ((CLRM/E)X((#RM X	Z3 + 0.5)XX	(E) -0.5XX(E))) / Z3	59.940	
	CIPS=CTB*Z4/Z2	and the second s	e Turin er en la <u>Galliane er en er e</u> En jegen er en er en	ورغ بداد باز هجه برسد در از از از	alia zaj takon ali	59.940	
	CRCI = CTB X R				•	0.0	
	CC&M = O&M OR CTB*Z	5/Z2/ENYR				0.0	
	COMMENTS						

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.2.3 SUPPORT STRUCTURE DDT&E

	INPUT PARAMETERS	INPUT COEFFICIENTS				
	T= 1.000000 TF= 1.000000 CDCE	R = 2.00000				
	M= 1.000000 0&M= 0.0 CDEX CF= 1.000000 Z1= 1.000000 CICE					
	PHI= 1.000000 Z2= 60.000000 CIEX					
	R= 0.0 Z3= 60.000000					
	DF= 1.000000 Z4= 60.000000 Z5=					
	CALCULATED VALUES SET SUM TO 1.4.2	\$,MILLIONS				
	CD=CDCER X (T X DF)XX(CDEXP) X CF	2.000				
	CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.0				
В	#RM =T / M	1.000				
B-274	E =1.0 + LOG(PHI) / LOG(2.0)	1.000				
!	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	0.0				
	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E))) /	Z3 0.0				
	CIPS=CTB*Z4/Z2					
	CRCI =CTB X R	0.0				
	CC&M = O&M OR CTB*Z5/Z2/ENYR	0.0				
	T <mark>romments</mark> in the first of the latter of the latter of the first of the latter of the					

1.4.3 POWER COLLECTION

This element of the GRS includes the rectenna array elements associated with the actual reception and rectification of the microwave radiation. These elements are in series and parallel as required to deliver the line output voltage and current. Also included are those components that accept the dc power from the array elements and route, control, convert, and switch this power for delivery to the power conversion stations of the grid interface.

The rectifier assembly consists of a GaAs diode and input/output filters. The outputs of the rectifier circuit are series connected to output $40+\,\mathrm{kV}$ (Figure 1.4-9). The regulation assembly accepts the voltage from the series connected rectenna diodes and adjusts the voltage output to the power distribution feeders to a value consistent with positive current flow. The rectenna array elements are 0.735×9.33 m in size and 20 elements are combined per panel with diode circuitry equivalent to the mW density pattern. A total of 735 diodes or diode equivalents are required per average panel with a rectenna total of 330×10^6 diodes as shown in Figure 1.4-10.

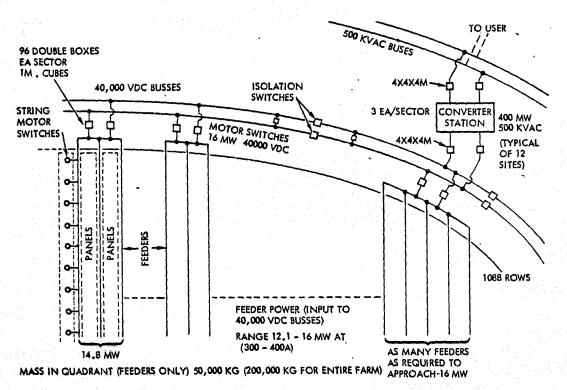


Figure 1.4-9. Rectenna Schematic Block Diagram
- Preliminary

The electronic array element of the antenna is a multilayered copper/dielectric sandwich panel material. Resource/mass projections are identified in Table 1.4-7. These calculations were based on the array cross section and panel requirements shown in Figure 1.4-11. Costs were determined from

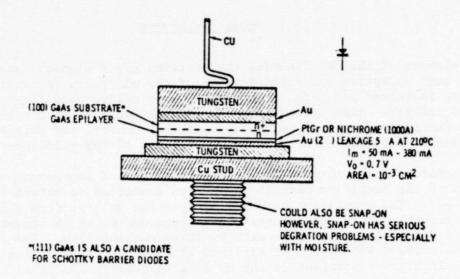


Figure 1.4-10. Diode Concept

Table 1.4-7. Resource Requirements Rectenna Dipole
- Bow-Tie - Panel Array Elements

580,500 RECTENNA PANEL	.S
• DIELECTRIC	
PLASTIC COMPOUND—3.5 LB/FT ³ , 0.4375 LB/FT ² x 856.4 x 10 ⁶ FT ²	374.68 x 10 ⁶ LB
• MYLAR	
0.001-IN. THICKNESS AT 87.36 LB/FT ³ , - 0.02913 LB/FT ² x 856.4 x 10 ⁶ FT ²	24. 95 x 10 ⁶ LB
• COPPER	
0.0039 THICKNESS AT 556.6 LB/FT ³ , 0.118753 LB/FT ² x 856.4 x 10 ⁶ FT ²	101. 70 x 10 ⁶ LB
• DIODES	
1 OZ. PER 426.67 x 106 DIODES OR EQUIV	26.67 x 10 ⁶ LB
TOTAL	528 x 10 ⁶ LB
	909. 6 LB/PANEL

estimating guides/industrial contacts and combined with the cost of switches and regulators needed at each panel to provide a total cost estimate of \$1942 for the antenna array elements.

The power collection and distribution system consists of all field feeders (collectors), supporting switchgear, 40 kV dc buses to the power converters, and the towers/footings needed to support the transmission lines. Approximately 330,000 switchgears, 10⁷ meters of feeder cables, miscellaneous junction boxes, etc., must be delivered and installed at the panel sites. Tractor/trailer trucks are used for this purpose and proceed through the panel rows,

Satellite Systems Division Space Systems Group



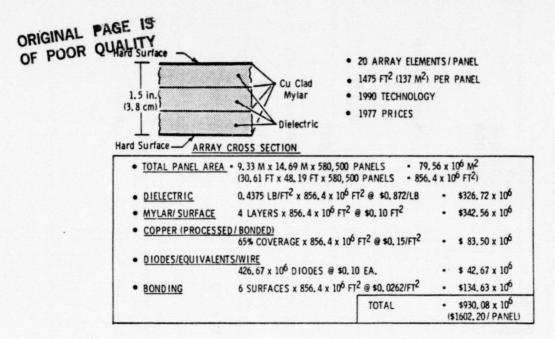


Figure 1.4-11. Rectenna Dipole - Bow-Tie - Panel Array Elements

delivering material at each panel. Additional trucks with reels playout the feeders, which then are installed in conduits and spliced to panel connections by the electrical installation crew. Contacts with a utility company indicate a requirement of 8 manhours to hookup one panel. On this basis, the manpower and equipment projections were established for a 20 hour 7 day week.

Equipment for electrical hookup and checkout of completed panels was calculated on the basis of acquisition cost prorated over the service life and utilization period at a particular site. Total crew requirements of 4196 personnel and the schedule period were the basis of calculating man-day requirements of 755,280. The amortized cost of equipment and labor were combined for the total cost factor.

DDT&E power collection costs are associated with the design and verification of bow-tie electronic panels/bonding processes, connectors, and large switchgear to optimize the voltage/current ratios and element/wiring configuration. Cost estimates are provided in the following areas:

Table 1.4.3.1 Antenna Array Elements
Table 1.4.3.2 Power Distribution System
Table 1.4.3.3 Installation and Checkout
Table 1.4.3.4 Power Collection DDT&E

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.3.1 ANTENNA ARRAY ELEMENTS

		INPUT P	ARAMETERS			INPUT	COEFFICIENTS	
	T =	580500.000	TF=	1.000000		CDCER=	0 • 0	
	M=	1.000000	=M30	0.0	are transfer to the	CDEXP=	0.0	
	CF=	1.000000	Z 1 =	1.000000		CICER=	0.001942	
	PHI=	1.000000	Z2=	60.000000		CIEXP=	1.000000	
	DF=	0.0 1.000000	Z3= Z4=	60.000000	25=	0.0		
	CALCUL	ATED VALUES	PANEL	SUM TO	1.4.3		\$,MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF				0.0	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF				0.002	
ᄧ 1	#RM =T / M						580500.000	
-278	E = 1.0 +	LOG(PHI) / LOG(2	•0)				1.000	
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -	0.5XX(E))			1127.331	
	CTB = ((CLRM	/E)X((#RM X Z	3 + 0.51XX	((E) -0.5XX(E))) / 23	1127.322	
	CIPS=CTB*Z4	472						
	CIESTERUTE	7 L L					1127.321	
	CRCI =	CTB X R					0.0	
	CO&M =	O&M OR CTB*Z5/Z2	/ENYR				0.0	
	COMMENTS							ne den en e
			+154 (1771) 					

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.3.2 POWER DISTRIBUTION SYSTEM

		INPUT P	ARAMETERS			INPUT COEFFICIENTS			
	Teller	580500.000	TF=	1.000000		CDCER=		0.0	
	M=	1.000000	=M30	0.0		CDEXP=	•	0.0	**************************************
	CF= PHI=	1.000000	Z1= Z2=	1.000000		CICER= CIEXP=		0.000120 1.000000	
	R=	0.0	Z3=	60.000000		CICAF-		1.00000	e rubi saje e
	DF=	1.000000	Z 4=	60.000000	25 =		0.0		
	CALCUL	ATED VALUES	PANEL	SUM TO	1.4.3			\$, MILLIONS	
	CD=CDCER X	(T X DF)XX(CDEXP) X CF			ا داد دید دانشد خود	Salaria Salaria Salaria	0.0	
	CLRM=CICER	X (M)XX(CIEXP) X	CF X TF					0.000	
B	#RM =T / M						58	30500.000	
B-279	E = 1.0 +	LOG(PHI) / LOG(2	•0)			و المحادث و المحادث ال	er a naturani dan sadan pada an kamban sanayan k	1.000	o compression of growing section (i.e., and any company).
	CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0).5XX(E))			98	69.660	
		1/E)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E)}		1 / Z3	40	69.659	
•	CIPS=CTB*Z4	+/22		The second secon		De Martine About about of the Community		69.659	
	CRCI =	CTB X R					PAGE IS	0.0	
	C08M =	OEM OR CTB*Z5/Z2	/ENYR				Zā	0.0	
	COMMENTS	and the second of the second o		The second secon	and the second seco				en en en en general personal de la companya de la La companya de la co

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.4.3.3 INSTALLATION & CHECKOUT

INPUT PARAMETERS	INPUT COEFFICIENTS
T= 781100.000 TF= 1.00000	
M= 4340.00000 0&M= 0.0 CF= 1.000000 Z1= 1.00000 PHI= 1.000000 Z2= 60.00000	
R= 0.0 Z3= 60.00000 DF= 1.000000 Z4= 60.00000	0
CALCULATED VALUES MANDAYS SUM TO	1.4.3 \$, MILLIONS
CD=CDCER X (T X DF)XX(CDEXP) X CF	
CLRM=CICER X (M)XX(CIEXP) X CF X TF	0.868
#RM =T / M	179.977
E =1.0 + LOG(PHI) / LOG(2.0)	1.000
CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))	156.220
CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -0.5XX(E)) / Z3 156.220
CIPS=CTB*Z4/Z2	156.220
CRCI = CTB X R	0.0
CORM = DRM OR CTB*Z5/Z2/ENYR	
COMMENTS	<u></u>

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.3.4 POWER COLLECTION-DDT&E

	INPUT PARAMET	ERS	INPUT CO	EFFICIENTS	
	T= 1.000000 TF=	1.000000	CDCER=	3.000000	
	M= 1.000000 06M=		CDEXP=	0.300000	
	CF= 1.000000 Z1=		CICER=	0.0	
	PHI= 1.000000 Z2=		CIEXP=	0.0	
	R= 0.0 Z3=	60.000000			
	DF= 1.000000 Z4=	60.000000	Z5 = 0.0		
	CALCULATED VALUES SE	T SUM TO A	.4.3 O S	\$, MILL IONS	•
	CD=CDCER X (T X DF)XX(CDEXP) X CF		<u> </u>	3.000	
	CLRM=CICER X (M)XX(CIEXP) X CF X	TF	ORIGINAL POOR C	0.0	
ᄧ	#RM =T / M		Ž Š Š	1.000	
281	E =1.0 + LOG(PHI) / LOG(2.0)		PAGE IS	1.000	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX(E))		0.0	
	CTB = ((CLRM/E)X((#RM X Z3 + 0.	5)XX(E) -0.5XX(E))) / Z3	0.0	
	CIPS=CTB*Z4/Z2	and a supplied to the supplied of the supplied		0.0	ا دائيد يا مسجده سيوند و د آ • آداد ياد داد ي
	CRCI =CTB X R			0.0	and the second s
· ·	CC&M = O&M OR CTB*Z5/Z2/ENYR			0.0	

1.4.4 CONTROL

and a new congression of the

The telemetry, tracking, communications, monitoring of microwave beam characteristics, computing phase corrections, and the equipment needed to provide frequency standard signals for the satellite are included in this section. This hardware will be used to monitor and control the satellite from the ground.

The following monitor and control functions are performed:

- 1. Tracking, using ground-based radars to monitor the orbital stability of the satellite.
- 2. Beam monitoring and control, using ground equipment for adaptive or command control of the satellite microwave beam.
- 3. Data management, using equipment required to analyze signals and data from the satellite and ground-based systems to compute control signals and corrective data to maintain safe and optimum performance.
- 4. Communications, using equipment required to maintain communications between the ground station and the SPS satellite. Included are the communications with the crew, and telemetry and command equipment not included in the beam monitoring and control assembly.

At this time, the cost effort is divided into the three categories of control center equipment, beam control electronics, and DDT&E. Two sets of full-up IBM 370, or equivalents, a complete display center, and a manned control room are envisioned as basic elements of the control center. Beam control electronics would consist of control sensors and dual frequency transmitters. The overall DDT&E and hardware costs were projected by engineering. The exacting requirement of this rectenna operation will require further study in future contract activity to define the technical and performance standards. It should also be noted that system and operational requirements are needed to define adequate software/programming considerations.

Cost estimates are presented as follows:

Table 1.4.4.1 Control Center Equipment

Table 1.4.4.2 Control Electronics

Table 1.4.4.3 Control DDT&E

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.4.1 CONTROL CENTER EQUIPMENT

	INPUT P	PARAMETERS		INPU	JT COEFFICIENTS	· · · · · · · · · · · · · · · · · · ·
T= M= C F= PH [=	1.000000 1.000000 1.000000 1.000000	TF= 0&M= Z1= Z2=	1.000000 0.0 1.000000 60.000000	CDCER= CDEXP= CICER= CIEXP=	0.0 0.0 15.000000 1.000000	
R= DF=	0.0 1.000000	23= 24=	60.000000 60.000000 Z5=	0	0.0	e e e e e e e e e e e e e e e e e e e
CALCUL	ATED VALUES	SET	SUM TO 1.4.4		\$, MILL IONS	
CD=CDCER X	(T X DF)XX(CDEXP) X CF			0.0	
CLRM=CICER	X (M)XX(CIEXP) >	CF X TF			15.000	
#RM =T / M	LOG(PH[) / LOG(2	· · · · · · · · · · · · · · · · · · ·			1.000	
CTFU=(CLRM	/ E)X((#RM X Z1+	.5)XX(E) -0.5)	(X(E))		15.000	
CTB = ((CLRM	/E)X((#RM X Z	3 + 0.5)XX(E)	-0.5XX(E))) / 23	15.000	
CIPS=CTB*Z4	/22	Andrew Grange (1994) in the con- traction of the contraction of the con- traction of the contraction of the con-			15.000	
CRCI =	CTB X R				<u> ភ្ន</u> ០.០	
CC&M =	O&M OR CTB*Z5/Z2	/ENYR			ORIG 0.0	
COMMENTS					PAGE IS	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.4.2 CONTROL ELECTRONICS

	그림 맞고 있다면 하는 그는 이번 이번 하는데 이번				
	INPUT PARAMETERS	And the second s	IN	IPUT COEFFICIENTS	Same with
	T= 1.000000 TF=	1.00000	CDCER=	0.0	
	M= 1.000000 0&M=	0.0	CDEXP=	0.0	····
	CF= 1.000000 Z1=	1.000000	CICER=	60.000000	
	PHI= 1.000000 Z2=	60.000000	CIEXP=	1.00000	and any or a second and an area.
	R= 0.0 Z3=	60.000000			
	DF= 1.000000 Z4=	60.000000	Z5 =	0.0	
	CALCULATED VALUES SET	SUM TO 1.4	. 4	\$, MILLIONS	S
	CD=CDCER X (T X DF)XX(CDEXP) X CF	tur 1944 - Grand Garley, G 1945 - Garley, Garley			
	CLRM=CICER X (M)XX(CIEXP) X CF X TF			60.000	
ਹ ਹ	#RM =T / M			1.000	an man <u>Imperior or party management of the services</u> of
78/	E =1.0 + LOG(PHI) / LOG(2.0)			1.000	
	CTFU=(CLRM / E)X((#RM X Z1+.5)XX(E) -0.5XX	((E))		60.000	
-	CTB = ((CLRM/E)X((#RM X Z3 + 0.5)XX(E) -	0.5XX(E))) / Z3	60.000	and the state of t
					e de la companya de La companya de la co
	CIPS=CTB*Z4/Z2			60.000	
	CRCI =CTB X R			0.0	
	CCEM = DEM OR CTB*Z5/Z2/ENYR			0.0	
	COMMENTS				

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.4.3 CONTROL DDT&E

	INPUT P	ARAMETERS		INPUT C	OEFFICIENTS	
T = M= CF= PHI = R= DF=	1.000000 1.000000 1.000000 0.0 1.000000	TF= 0&M= Z1= Z2= Z3= Z4=	1.000000 0.0 1.000000 60.000000 60.000000	CDCER= CDEXP= CICER= CIEXP= 5= 0.0	10.000000 1.000000 0.0 0.0	
CALCULAT	ED VALUES	SET	SUM TO 1.4.4		\$, MILL TONS	is seems prosper en
CD=CDCER X (T	X DF)XX(CDEXP	X CF			10.000	
CLRM=CICER X	(M)XX(CIEXP) X	CF X TF			0.0	
#RM =T / M					1.000	
F =1.0 + LO	G(PHI) / LOG(2.	.0)			1.000	
CT FU= (CLRM /	E)X((#RM X Z1+	.5)XX(E) -0	.5XX(E))		0.0	
CTB = ((CLRM/E)X((#RM X Z:	3 + 0.5)XX(E) -0.5XX(E))) / Z3 🝣	0.0	
CIPS=CTB*Z4/Z	2			QUALITY YALITY	0.0	
CRCI =CT	B X R			5.	0.0	
COEM = DE	M OR CTB*Z5/Z2	'ENYR				

1.4.5 GRID INTERFACE

This element includes the power conversion equipment that receives electrical power from the power collection system and conditions/converts it to a high voltage dc or ac power acceptable for input into the national power grid.

The converter stations accept 40 kV dc power and output 500 kV ac or dc. The concept utilizes a solid-state inversion/step-up concept typified by an existing dc - ac conversion station located in Sylmar, California. Although specific design details of this system await clarification in a future study effort, an analysis and cost estimate was prepared as shown in Table 1.4-8. The CER for DDT&E were derived from cost estimates in the "Technical Study Report on Pacific Northwest-Southwest dc inter-tie," prepared by the Bonneville Power Administration in February, 1976. This DDT&E estimate was based on six cost quotations which Bonneville received on a 1.44 GW and a 2.20 inter-tie. The total cost for the 1.44 GW terminal (\$156.7 $\overline{\text{M}}$) was allocated as 30% DDT&E and 70% ICI. This judgment was based on the assumption that most of the facility will be a standard design.

Table 1.4-8. Grid Interface (WBS 1.4.5)

ITEM DESCRIPTION	SPECIFICATION	GRS QUANTITY	PROJECTED UNIT COST	TOTAL (1977 \$)
CONVERTER STATIONS	400 mW 500 kV ac or kV dc	12 EA.	\$10×10 ⁶	\$120×10 ⁶
ISOLATION SWITCH- GEAR	4×4×4 m	24 EA	\$400,000 EA	\$0.96×10 ⁶
FILTER YARDS		12	\$100,000 EA	\$1.2×10 ⁶
INTERCONNECT TOWERS & FOUNDATION	500 kV ac TOWERS	90 EA		\$12.741×10 ⁶
INTERCONNECT TRANSMISSION CABLE		12 LINES	\$90,000/MI	\$10.789×10 ⁶
TOTAL/GRS				\$145.69×10 ⁶

Cost estimates are presented in Table 1.4.5.1 on electrical equipment and in Table 1.4.5.2 on DDT&E.

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.5.1 ELECTRICAL EQUIPMENT

	INPUT P	ARAMETERS		INPUT COEFFICIENTS					
	1.000000	TF=	1.000000	CDCER=	0.0	no mang ang ang ang ang ang ang ang ang ang			
M=	1.000000	=M3O	0.0	CDEXP=	0.0				
CF=		Z 1 =	1.000000		145.690002				
PHI=	1.000000	Z2=	60.000000	CI EXP=	1.000000				
R=	0.0	Z3=	60.000000 60.000000	Z5= 0.0		· · · · · · · · · · · · · · · · · · ·			
DF=	1.000000	Z 4=	60.00000	25-					
CALCULA	TED VALUES	SET	SUM TO 1.4.	5	\$, MILLION	S			
CD=CDCER X	T X DF)XX(CDEXP) X CF			0.0				
CLRM=CICER X	((M)XX(CIEXP) >	C CF X TF			145.690				
#RM =T / M		and a second control of the second control o			1.000	er meg epite a spendage – e jake beringk militarbase e eg			
E = 1.0 + L	.ng(PHI) / LOG(2	.0)			1.000				
CTFU=(CLRM /	' E)X((#RM X Z1+	5)XX(E) -	0.5XX(E))		145.690				
CTB = ((CLRM)	'E)X((#RM X 2	3 + 0.5)XX	(E) -0.5XX(E))) / Z3	145.690	- The second			
CIPS=CTB*Z4/	1 72				145.690				
CRCI = (CTB X R				0.0				
CO&M = (D&M OR CTB*Z5/Z2	!/ENYR		OF THE	0.0				
COMMENTS				OF POOR					
				۾ ا	e Car				
				- Qu	R				
		official and a section of							

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.5.2 GRID INTERFACE-DDT&E

	INPUT P	ARAMETERS			INPUT CO	EFFICIENTS	
T= M= CF= PHI= R= DF=	5.000000 5.000000 1.000000 0.0 1.000000	TF= 0&M= Z1= Z2= Z3= Z4=	1.000000 0.0 1.000000 60.000000 60.000000	CDCE CDEX CICE CIEX	(P= R=	37.714996 0.604000 0.0 0.0	
CALCULAT	ED VALÜES	GW	SUM TO 1.	4.5	and the same of th	\$, MILLIONS	and the same and a second
CD=CDCER X (T	X DF)XX(CDEXP) X CF				99.699	
CLRM=CICER X	(M)XX(CIEXP)	CE X TE				0.0	•
#RM =T / M		ng nganasiya dagan, arinny dagan tenganay yilan bira a sayah bilindiri. Alba sana				1.000	The sentence With Section 25, E
E =1.0 + LO	G(PHI) / LOG(2	·•0)				1.000	
CTFU=(CLRM /	E)X((#RM X Z1+	.5) XX(E) -0).5XX(E))			0.0	
CTB = ((CLRM/E	:)X((#RM X Z	3 + 0.5)XX(E) -0.5XX(E))	*	7 23	0.0	A STATE OF THE STA
CIPS=CTB*Z4/Z						0.0	
CRCI =CT	B X R	and the second s				0.0	عقاضي بإيلاد الشفات
30 = M303	M OR CTB*Z5/Z2	!/ENYR				0.0	
COMMENTS							

1.4.6 OPERATIONS

This element includes the planning, development, and conduct of operations at the ground receiving station. It includes both the direct and support personnel and the expendable maintenance supplies required for the ground station operation and maintenance.

Operations and maintenance personnel required after IOC are identified as a 300 personnel staff to provide a 24 hour operation, maintenance/repair, security, and administrative support (Table 1.4-9). A cost estimate for maintenance material (expendables, trucks, and equipment); standby auxiliary power; and test/support equipment is also identified in the table.

ITEM	SHIFT	NO.	TOTAL	1977 DOLLARS
OPERATIONS & MAINTENANCE PERSONNEL				
COMMAND & CONTROL CENTER (PERSONNEL + SUPERVISORY)	1 2 3	30 30 20	80	
CONVERTER STATION (TOTAL FOR 12 STATIONS)	1 2 3	36 36 36	108	
24-HOUR MAINTENANCE, REPAIR, SECURITY, ε GεA/SUPPORT		112	112 300	
MAINTENANCE MATERIAL				\$13.13×10 ⁶
EXPENDABLES, TRUCKS, EQUIP., UTILITIES, TEST/SUPPORT EQUIP.				

Table 1.4-9. Operations Requirements

Cost estimates are shown in Table 1.4.6.1 for operations and maintenance personnel and in Table 1.4.6.2 for maintenance material.

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ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.6.1 OPER. & MAINT. PERSONNEL

	INPUT PARAMETER		INPUT CO	EFFICIENTS
T= M= CF= PHI= R= DF=	300.000000 TF= 300.000000	1.00000 64.80003 1.00000 60.00000 60.00000 60.000000	CDCER = CDEXP = CICER = CIEXP =	0.0 0.0 0.0 0.0
CALCULA	ATED VALUES MAN-DAYS	SUM TO 1.4.6	and an internal and a second and	\$, MILL IONS
CD=CDCFR X	(T X DF)XX(CDEXP) X CF			0.0
CLRM=CICER X	((M)XX(CIEXP) X CF X TF			0.0
#RM =T / M			d majahan sana di manan mananan ya di masa sana na manana di manana di manana di manana manana manana manana m	1.000
E = 1.0 + L	.DG(PHI) / LDG(2.0)			1.000
CTFU=(CLRM /	' E)X((#RM X Z1+.5)XX(E)	-0.5XX(E))		0.0
CTB = ((CLRM/	/E)X((#RM X Z3 + 0.5))	XX(E) -0.5XX(E))) / Z3	0.0
CIPS=CTB*Z4/	′22			0.0
CRCI = 0	CTB X R			0.0
CO&M = C	DEM OR CTB*Z5/Z2/ENYR			64.800
COMMENTS 360 DAYS	S/YR * 3 SHIFTS/DAY * 300	D MANDAYS/SHIFT * \$200/	MA ND AY	

ROCKWELL SPS CR-2 REFERENCE CONFIGURATION TABLE 1.4.6.2 MAINT. MATERIAL

	INPUT P	ARAMETERS		INPUT COEFFICIENTS						
	1.000000	TF=	1.000000	CDCER=	0.0					
M=10 10 10 10 10 10 10 10 10 10 10 10 10 1	1.000000	=M30	13.130000	CDEXP=	0.0					
CF≐ CF≐	1.000000	Z 1 =	1.000000	CICER=	0.0					
PHI=	1.000000	Z2=	60.000000	CIEXP=	0.0					
	0.0	Z3=	60.000000							
DF=	1.000000	Z 4=	60.000000	Z5=	0.0					
CALCULATED	VALUES	SET	SUM TO	1.4.6	en e	\$, MILL IONS	a ayang daring dalah dalah sebagai persasah sebagai banda ya dari ba			
CD=CDCER X (T X	DF1XX(CDEXP) X CF	of a february and the Allen			0.0				
CLRM=CICER X (M)	XX(CIEXP) X	CF X TF				0.0				
#RM =T / M					1.	.000				
E = 1.0 + LOG(P	HI) / LOG(2	.0)				.000				
CTFU=(CLRM / E)X	(.5)XX(E) -0	.5XX(E))			0.0				
معاملية والمدارع المراجع المر	<u></u>			. Livery of the state of the st		e country of other my and man deposition of the decided methodological for the decided and methodological for the decided and methodological for the decided and d	and the state of t			
CTB = ((CLRM/E)X((#RM X Z	3 + 0.5) XX(E) -0.5XX(E))) / Z		0.0				
CIPS=CTB*Z4/Z2						0.0	an an in the second			
CRCI = CTB	X R	ing and the second section of the secti				0.0				
O M3O = M3OO	R CTB*Z5/Z2	/ENYR				13.130				
COMMENTS										

1.5 MANAGEMENT AND INTEGRATION

This element includes all efforts and material required for management and integration functions at the systems level and program level. It encompasses the following functions:

- 1. Program Administration
- 2. Program Planning and Control
- 3. Contracts Administration
- 4. Engineering Management
- 5. Manufacturing Management
- 6. Support Management
- 7. Quality Assurance Management
- 8. Configuration Management
- 9. Data Management
- 10. Systems Engineering and Integration.

This element sums all of the direct effort required to provide management control including planning, organizing, directing, and coordinating the project to ensure that overall project objectives are accomplished. These efforts overlay the functional work areas (e.g., engineering, manufacturing, etc.) and assure that they are properly integrated. This element also includes the efforts required in the coordination, gathering, and dissemination of management information. Also included are the engineering efforts related to the establishment and maintenance of a technical baseline for a system by generation of system configuration parameters, criteria, and requirements. It includes requirements analysis and integration, system definition, system test definition, interfaces, safety, reliability, and maintainability. It also includes those efforts required to monitor the system development and operations to ensure that the design conforms to the baseline specifications.

The management and integration function for DDT&E, TFU: ICI, RCI and O&M are estimated at a cost equal to 5% of the corresponding total dollar estimates for WBS elements 1.1 through 1.4 within each area. Table 1.5 presents this tabulation.

RUCKWELL SPS CR-2 REFERENCE CONFIGURATION
TABLE 1.5 MANAGEMENT AND INTEGRATION

	INPUT P	AR AMETERS		INPUT COEFFICIENTS				
]= M= CF= PHI= K= DF=	0.0 0.0 0.0 1.000000 0.6 1.000000	υβ M= 21= 22= 25=	1.005000 0.0 1.000000 60.000000 60.000000 60.000000	CDCER CDEXP CICER CIEXP 25=	= 0 = 0 = 0	• 6 • 0 • 0		
CALCULA	TED VALUES 5	å * ALL	SUM TU 1			\$,MILLIONS		
CD=CDCER X (T X DF)XX(CDEXP) X CF				1392,463		
CLKM=CICER X	(M)XX(CIEXP) X	CF X TF				0.0		
RM = 1 / M		Anna Congress Shapped Co. San Wilson Co.				0.0	The second secon	
_ш Е =1.0 + Ц	OG(PH1) / LUG(2	.0)				0.0	ing the second s	
CIFU= (CLRM /	E)X((AKM & Z1+	.5)XX(E) -C	.5XX(E))			2151.918		
CTD = ((CLRM/ C1PS=CTE#Z4/ CKC1 =C			E) -9.5XX(E))		Z3	0.0 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		
	&M UR C16*25/22	ZelkYk				8.561 QUALITY	•	
CALCULAT	U.ICI.KCI. AND ED AT 5% OF COR 1.1 THROUGH 1.4	RESPONEING	TOTALS			₹ 5		

1.6 MASS CONTINGENCY

A cost contingency has been added to the SPS Program to provide for potential growth due to increased weight as a result of design/development activities that would affect the procurement of systems during any phase of the program. This allowance is costed as a 15% bottom line contingency to the DDT&E, TFU, ICI, RCI and O&M elements of the program. Table 1.6 reflects the total amounts in each of these areas based on the totals of items 1.1, 1.2, and 1.3.

	RUCKWELL SES	CK-2 REFERE	NCE	CONFIGUR	KATIUN	
TABLE 1.6	MASS C	UNT INGENCY				

	INPUI	PAKAMETERS			INP	UT COE	FFICIENTS		
T= M= C+= PHI= K= DF=	6.0 0.0 0.0 1.000000 0.0 1.600000	1 F= 11 E M= 2 1 = 2 2 = 2 3 = 2 4 =	1.000000 0.0 1.000000 60.00000 60.000000	25 =	CDCER= CDEXP= CICER= CIEXP=	0.0	0.0 0.0 0.0 0.0		
CALCULAT	TED VALUES	والمواد الموادية والموادية	SUM TO 1				\$,MILLI	ONS	
CD=CDCER X (T X DF)XX(CDLX	(P) X CH					4160.031		
CLRM=CICER X	(M)XX(C1EXP)	X CF X 1F					0.0		
# KM = 7 / M	an ing magana sa mga mana sa manananan an mana m anangsa an Mga mga mga mga mga mga mga mga mga mga m						0.0		
E =1.0 + L0	06(PHI) / LUG	2.64				and the second s	0.0	76	
CTFU= (CLKM /	E) X ((#KM X Z1	+.5)XX(£) -0	.5XX(E))				5912.945	OF POOR	
CTH = ((CLRM/)		Z3 + 6.0)xx(1	e) -0.5XX(E))) / 23		0.0 1263.413	PAGE	
CRCI =C	TB X K				and the second s	بجروات كالما الكاميات لينتو	56 <u>.</u> 405	75	and the designation of the series of the ser
C () է Ի\ = Մ	EM UR CTL*25/2	(2/ENYK					13.927		
	SS CONTINGENCY COST CONTINGE		1.2, 1.3						er en